

UNITED STATES AIR FORCE ARMSTRONG LABORATORY

Pilot Demonstration of Nitrate-Based Bioremediation of Fuel-Contaminated- Aquifer at Eglin AFB, Florida: Site Characterization, Design, and Performamnce Evaluation

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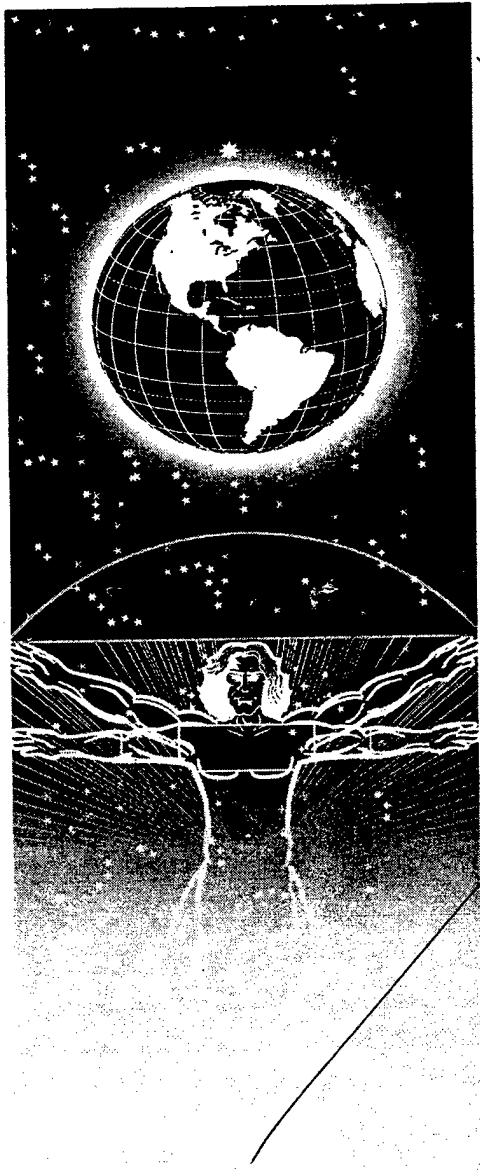
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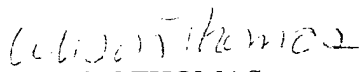
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PREFACE

This report was prepared by the United States Environmental Protection Agency's Robert S. Kerr Environmental Research Laboratory, P.O. Box 1198, Ada, OK 74820, under Contract MIPR 92-08 for HQ, USAF/CEVR, Bolling Air Force Base, Building 516, Washington, DC, 20332-5000, and Contracts MIPRs 92-65, 93-20, and 93-70 for the Armstrong Laboratory Environics Directorate (AL/EQ), Suite 2, 139 Barnes Drive, Tyndall Air Force Base, Florida 32403-5319.

This project focuses on research conducted for design, construction, and operation of an *in-situ* pilot demonstration system for nitrate-based bioremediation of a shallow water-table aquifer contaminated with JP-4 jet fuel at Eglin AFB, FL. Because this project encompasses the work of several research efforts to provide a thorough site characterization and performance evaluation of the field project, some of these research efforts have been published separately and will only be summarized here. This report primarily describes RSKERL's efforts, including the site characterization, design, and operation of the pilot system, an interim performance evaluation based on the first 4 months of operation, and a final performance evaluation based on an additional 8 months of operation. In addition, this report describes laboratory microcosm studies conducted before, during, and after operation of the pilot demonstration system to evaluate the contribution of specific microbial processes to *in situ* bioremediation.

The authors would like to thank the following groups and individuals for their support and cooperation: (1) Mr. Frank Beck et al, RSKERL, for field support in drilling and well construction, (2) Mr. Stephen Williams, Environmental Restoration Program, Eglin AFB, for providing oversight and coordinating access to the field site, (3) Mr. Guy Willis, EA Engineering, for providing monitoring and sampling services, (4) Ms. Barbara Wilson et al, RSKERL, for providing project support, (5) Dr. John Wilson et al, RSKERL, for providing technical advice, (6) ManTech Environmental Research Services Corporation, for providing analytical support, (7) Computer Data Systems Inc, for graphics, mapping, contouring, and modeling services, and (8) EA Engineering, for pilot system design and construction. Although the research described in this paper has been funded wholly or in part by the U.S. Environmental Protection Agency, it has not been subjected to Agency review and therefore does not necessarily reflect the views of the Agency, and no official endorsement should be inferred.

The work was performed between October 1992 and September 1996. The AL/EQM project officer was Ms Alison Thomas.

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EXECUTIVE SUMMARY

A. OBJECTIVE

The objective of this research was to compare the extent of bioremediation of a fuel-contaminated aquifer using aerobic recharge with and without nitrate addition. This research was undertaken to provide a direct comparison through operation of a pilot project at a JP-4 jet fuel-contaminated aquifer at Eglin AFB, FL. Subobjectives of this research were to: (1) provide a thorough site characterization to delineate contaminant distribution and microbial activity in the aquifer, (2) conduct field and laboratory tests to provide design parameters for construction and operation of the pilot system, (3) design, construct, and operate a pilot system to provide a direct comparison of the effects of recharge with and without nitrate amendments, (4) use core and water analyses to compare the extent of benzene, alkylbenzene, and JP-4 removal in the two treatment areas, (5) evaluate changes in microbial populations and sediment toxicity as a result of nitrate-based bioremediation, and (6) conduct post-test treatability studies to better elucidate the respective microbial roles.

B. BACKGROUND

Leaking underground storage tanks are a major source of ground water contamination by petroleum hydrocarbons. Gasoline and other fuels contain benzene, toluene, ethylbenzene, xylenes, and trimethylbenzenes (collectively known as BTEXTMB) which, although being relatively water-soluble, are contained in the immiscible bulk fuel phase that serves as a slow-release mechanism for sustained ground water contamination. Pump-and-treat technology alone is economically impractical for renovating aquifers contaminated with bulk fuel, because the dynamics of immiscible fluid flow result in prohibitively long time periods for removal of the organic phase. In many cases, the problem is mitigated through the use of *in situ* aerobic bioremediation, which involves the addition of nutrients and oxygen (or hydrogen peroxide) to the contaminated areas so that the indigenous microbial populations can degrade the contaminants. Although aerobic bioremediation has been successfully applied, difficulties relating to aquifer plugging and oxygen mass transport are often encountered in inducing aerobic conditions by addition of oxygen or hydrogen peroxide to the subsurface environment.

Nitrate can also serve as an electron acceptor and results in anaerobic biodegradation of organic compounds via the processes of nitrate reduction and denitrification. Because nitrate is less expensive and more soluble than oxygen, it may be more economical to remediate fuel-contaminated aquifers using nitrate rather than oxygen. Several investigators have demonstrated that monoaromatic hydrocarbons can be degraded under denitrifying conditions. In general, laboratory studies have shown that alkylbenzenes are degraded whereas benzene is recalcitrant when nitrate is used as the sole electron acceptor. However, these processes are not well

understood at field scale, where several other processes, including aerobic biodegradation, can proceed concomitantly. Although there have been several field studies on nitrate-based bioremediation of fuel-contaminated aquifers, none have involved the use of a control site, where water is recirculated without nitrate addition. Therefore, the relative contributions of nitrate to BTEXTMB biodegradation in these field studies require further clarification.

C. SCOPE

Research has shown that monoaromatic hydrocarbons, with the possible exception of benzene, can be degraded and in many cases mineralized under denitrifying conditions. In addition, other studies have shown that fuel constituents such as polycyclic aromatic hydrocarbons can be degraded under denitrifying conditions; the same holds true for aerobic breakdown products of fuel hydrocarbons, such as phenols, alcohols, and aromatic acids. However, these types of compounds will, in general, be much more readily degraded under aerobic versus denitrifying conditions. Given the problems inherent in promoting aerobic biodegradation of fuel hydrocarbons in anaerobic aquifers, there are significant advantages to using nitrate to supplement rather than replace oxygen for *in situ* bioremediation. From a practical standpoint, several processes can be expected to occur under nitrate-based bioremediation because of the heterogeneity of aquifers and the establishment of microenvironments. In field tests to date, this has complicated the interpretation of the relative benefit of providing nitrate for *in situ* bioremediation.

The objective of this research, then, was to compare the extent of bioremediation using aerobic recharge with and without nitrate addition. Our intent was not to eliminate the other biotic and abiotic processes which might be operating concomitantly with nitrate reduction, but to evaluate the benefit of providing nitrate as a supplemental electron acceptor under field conditions. In addition, this project provided an opportunity to evaluate whether nitrate-based bioremediation would have any effect on native microbial populations or background toxicity.

D. METHODOLOGY

A progression of research activities was carefully coordinated to develop a comprehensive field study. First, in-house work was coordinated through cooperative agreements with Rice University and Oklahoma State University to provide a thorough initial site characterization. Work done in-house focused on: (1) feasibility studies on microbial performance using laboratory microcosms, (2) field sampling and analyses for distribution of contaminants, biomass estimates, and soil nutrient status, and (3) field sampling to provide water and aquifer material for the above tasks and for other researchers. Work done at Oklahoma State University focused on evaluation of sediment toxicity using FETAX, an assay based on development of frog embryos. Work done at Rice University focused on: (1) evaluation of microbial ecology using standard

counting procedures, (2) cone penetrometer and infiltration testing for hydrological characterization of the aquifer, and (3) laboratory column studies for evaluation of aquifer plugging potential. This information was used to design the pilot project, which consisted of two adjacent 100-foot x 100-foot cells that received nitrate-amended and unamended recharge, respectively, through sprinkler application. Performance was continuously monitored through the use of both conventional and cluster wells, located within and outside of the treatment cells. Performance evaluations, consisting of extensive chemical, microbial, and toxicological analyses of aquifer sediments and ground water, were conducted after 4 and 12 months of operation to provide a thorough evaluation of the extent of nitrate-based bioremediation.

E. TEST DESCRIPTION

The initial site characterization was conducted Mar 20-25, 1993, with laboratory and column microcosm testing being initiated afterwards. Based on this and additional site characterization work conducted in July, a conceptual design plan was prepared and submitted Oct 1993 to Armstrong Laboratory, Environics Directorate for review. The plan was accepted and construction was begun Mar 94. Two 100-foot x 100-foot treatment cells were delineated for treatment, one of which received ground water recharge amended to yield 10 mg/L $\text{NO}_3\text{-N}$ and the other which received no amendments. Nutrients were not added, because microcosm tests indicated that they were not required for this near-surface soil. The treatment cells were located downgradient of the original fuel spill area. Other than a raised berm overlying a shallow plastic barrier extending 2.5-4.5 feet into the subsurface between the two cells, there was no surface or subsurface construction for hydraulic containment. Application was by continuous sprinkler at 11 gpm/cell. Separate tracers were added to the sprinkler recharge waters for each of the two treatment cells during the first 2-week interval, and movement of tracers and nitrate were monitored routinely through the use of both conventional fully-penetrating wells with 10-ft screens and special cluster wells with 5-cm screens.

Operation began Apr 7, 1994, concomitant with the first tracer study, and a second tracer study was conducted Jun 1994. Nitrate levels were increased to 15-20 mg/L $\text{NO}_3\text{-N}$ on Jul 15, 1994. An Interim Performance Evaluation was conducted Aug 19-30, 1994. Core samples were obtained for contaminant distribution, treatability studies, microbial characterization, and toxicological evaluation. Water samples were obtained from geoprobe points and lysimeters. Because lysimeter data indicated incomplete transfer of nitrate within the Nitrate Cell, a 30-foot x 30-foot plot inside each cell was stripped of vegetative cover on Nov 14-16, 1994, and covered with weed barrier to enhance nitrate transfer into the subsurface. The Final Performance Evaluation was conducted May 13-30, 1995, and the pilot project was discontinued.

F. RESULTS

The initial site characterization demonstrated that: (1) the fuel was distributed 3-7 feet below ground surface, (2) the fuel was depleted in benzene and toluene, (3) the aquifer was anaerobic, (4) there was a large, viable, and active microbial population, (5) selected alkylbenzenes were degraded under denitrifying conditions, (6) surface application would be an effective delivery system, (7) recirculation of recharge water would plug the aquifer due to colloidal material, and (8) the fuel-contaminated aquifer was toxic relative to background core samples, based on FETAX. Once pilot operation began, tracer studies demonstrated transfer of the recharge through the contaminated interval. A total of 94 kg $\text{NO}_3\text{-N}$ was delivered to the Nitrate Cell over the first four-month period. Water quality analyses demonstrated that the system was actively denitrifying, but lysimeter samples showed that much of the nitrate was consumed within the rhizosphere above the fuel-contaminated interval. In addition, some of the cores obtained during the Interim Performance Evaluation apparently contacted more contaminated regions than those obtained for the initial site characterization. The Interim Performance Evaluation consequently demonstrated little removal of contaminants.

After an additional eight months operation, during which the stripped plots were installed, an additional 300 kg $\text{NO}_3\text{-N}$ was added to the Nitrate Cell. Lysimeter samples showed increased nitrate transfer to the contaminated interval beneath the stripped plot, and the Final Performance Evaluation demonstrated higher fractional removal of contaminant groups beneath the stripped plots as well. In general, there was no difference in performance between the Nitrate Cell and the Control Cell based on overall contaminant mass removal across each cell. However, there was higher fractional contaminant mass removal of many of the isomers in the Nitrate Cell stripped plot compared to the Control Cell stripped plot. Based on core data from the Interim and Final Performance Evaluations, BTEXTMB was reduced by $66 \pm 1\%$ in both treatment cells, equivalent to a mass loss of 106 kg and 21 kg in the Nitrate Cell and Control Cell, respectively. In contrast, JP-4 decreased by 37% (2170 kg) in the Nitrate Cell and increased by 11% (210 kg) in the Control Cell. Monitoring well data provided evidence of sulfate reduction in the Control Cell, but not in the Nitrate Cell. In addition, post-test treatability studies demonstrated active BTEXTMB removal in the upper zone of the Nitrate Cell under both denitrifying and iron-reducing conditions. However, only toluene was degraded under iron-reducing conditions in the corresponding upper Control Cell zone. Mesitylene, which is labile under denitrifying conditions, was removed to a greater extent in the Nitrate Cell than in the Control Cell. Treatability studies conducted with post-test core material demonstrated removal of alkylbenzenes and mineralization of *m*-xylene under denitrifying, iron-reducing, sulfate-reducing, and methanogenic conditions. These data collectively indicate that biotic processes, probably related to BTEXTMB removal, were occurring in both

treatment cells, although to various extents in the different regions.

Microbial populations, including protozoa, increased during the first 4 months of operation and then declined afterwards, although microbial numbers were generally higher in the deeper zones than before bioremediation commenced. In addition, the soil nutrient status generally increased, due to elevation of the soil pH and production of ammonia-nitrogen through dissimilatory nitrate reduction. Although results were quite variable, sediment toxicity generally decreased across the site. Collective laboratory and field data indicated that contaminant reduction occurred as a result of both anaerobic bioremediation and soil washing.

G. CONCLUSIONS

It is difficult to quantitatively evaluate the success of nitrate-based bioremediation in this pilot demonstration project because of three factors: (1) due to biological processes in the rhizosphere, nitrate was not uniformly and consistently delivered to the contaminated interval, (2) other biological processes in the Control Cell allowed bioremediation to proceed there as well as in the Nitrate Cell, and (3) near-surface site heterogeneities did not allow for even distribution of recharge and complicated the performance evaluation based on random core samples. Regardless, recharge application had a positive effect in both cells, resulting in decreased contaminant loads, increased nutrient distribution, increased microbial populations, and decreased sediment toxicity. In addition, penetration of tracers through the contaminated intervals showed that this method could be used to bioremediate shallow spills in anaerobic aquifers, without oxygen addition and the associated plugging problems. Removal of the vegetative cover facilitated nitrate transport in the Nitrate Cell, which accelerated contaminant removal relative to the corresponding Control Cell. Monitoring well data, geoprobe data, core data, and treatability studies all substantiate the occurrence of *in situ* bioremediation. Although the relative contribution of biodegradation to BTEXTMB removal cannot be accurately determined, laboratory and field data collectively indicate that it was a significant process in contaminant reduction.

H. RECOMMENDATIONS

To derive the answers to satisfy the original objectives, this project should be repeated at a smaller scale to better control site heterogeneity and facilitate nitrate transport to the subsurface. However, performance of the pilot project was good, and demonstrated that subsurface microbial activity could be stimulated through sprinkler application of recharge containing natural as well as added electron acceptors. Although it was deemed impractical in this study, the continuous addition of multiple and/or alternating tracers would provide the more quantitative data needed for modeling the relative contributions of biodegradation to contaminant removal. This approach should be investigated at field scale with a more homogeneous aquifer using multiple electron acceptors to enhance anaerobic bioremediation.

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INTRODUCTION

A. OBJECTIVE

Previous field work at the U.S. Coast Guard Facility in Traverse City, Michigan, had shown that alkylbenzenes in an aquifer contaminated with JP-4 jet fuel could be degraded by the indigenous microorganisms under denitrifying conditions. However, the lack of a suitable control site precluded a direct assessment of the benefits of nitrate addition relative to infiltration recharge without nitrate amendments. Without such a comparison, the economics of nitrate-based bioremediation versus pump-and-treat methods could not be determined. The following research was therefore undertaken to better define the control parameters and provide a direct comparison through operation of a pilot project at a JP-4 jet fuel-contaminated aquifer at Eglin AFB, FL. The objectives of this research were to:

- (1) provide a thorough site characterization to delineate contaminant distribution and microbial activity in the aquifer,
- (2) conduct field and laboratory tests to provide design parameters for construction and operation of the pilot system,
- (3) design, construct, and operate a pilot system to provide a direct comparison of the effects of recharge with and without nitrate amendments,
- (4) use core and water analyses to compare the extent of benzene, alkylbenzene, and JP-4 degradation in the two treatment areas,
- (5) evaluate changes in microbial populations and sediment toxicity as a result of nitrate-based bioremediation,
- (6) conduct post-test treatability studies to better elucidate the respective microbial roles, and

B. BACKGROUND

Leaking underground storage tanks are a major source of ground water contamination by petroleum hydrocarbons. There are approximately 1 million underground tanks storing gasoline in the U.S., and 270,000 confirmed releases have been reported in the last 6 years (OUST, 1994). Gasoline and other fuels contain benzene, toluene, ethylbenzene, and xylenes (collectively known as BTEX) which are hazardous compounds regulated by the U.S. Environmental Protection Agency (EPA, 1977). Although these aromatic hydrocarbons are relatively water-soluble, they are

contained in the immiscible bulk fuel phase which serves as a slow-release mechanism for sustained ground water contamination. Pump-and-treat technology alone is economically impractical for renovating aquifers contaminated with bulk fuel, because the dynamics of immiscible fluid flow result in prohibitively long time periods for removal of the organic phase (Wilson and Conrad, 1984; Bouchard et al., 1989). In many cases, the problem is mitigated through the use of *in situ* aerobic bioremediation, which involves the addition of nutrients and oxygen (or hydrogen peroxide) to the contaminated areas so that the indigenous microbial populations can degrade the contaminants (Thomas et al, 1987; Lee et al, 1988; Atlas, 1991). Although aerobic bioremediation has been successfully applied (Raymond et al, 1978; Lee and Raymond, 1991; Bell and Hoffman, 1991), difficulties relating to aquifer plugging and oxygen mass transport are often encountered in inducing aerobic conditions by addition of oxygen or hydrogen peroxide to the subsurface environment (Wilson et al, 1986; Barker et al, 1987; Aggarwal et al, 1991).

Nitrate can also serve as an electron acceptor and results in anaerobic biodegradation of organic compounds via the processes of nitrate reduction and denitrification (Tiedje, 1988). Because nitrate is less expensive and more soluble than oxygen, it may be more economical to remediate fuel-contaminated aquifers using nitrate rather than oxygen. Several investigators have demonstrated that monoaromatic hydrocarbons can be degraded under denitrifying conditions. Zeyer et al (1986) showed that toluene and *m*-xylene could be mineralized under denitrifying conditions in laboratory aquifer columns, and a pure culture was subsequently obtained with the same activity (Dolfing et al, 1990). The *m*-xylene-adapted microorganisms were unable to utilize benzene, ethylbenzene, and *o*- and *p*-xylene (Kuhn et al, 1988). Major et al (1988), using aquifer material, observed biodegradation of benzene, toluene, and all three xylene isomers under denitrifying conditions. Hutchins et al (1991a) found that toluene, ethylbenzene, xylenes, and 1,2,4-trimethylbenzene were degraded by aquifer microorganisms under denitrifying conditions, whereas benzene was recalcitrant. However, Trizinsky and Bouwer (1990) observed biodegradation of benzene, toluene, and *m*-xylene in batch enrichment cultures, although *o*-xylene removal did not begin until the previous substrates were depleted. In contrast, other researchers have observed cometabolic biotransformation of *o*-xylene (Evans et al, 1991; Jørgensen and Aamand, 1991). Hutchins (1993) conducted microcosm tests with nonacclimated and acclimated aquifer material from Traverse City, MI, to assess the extent of biodegradation of radiolabeled BTEX as single substrates. The rates and extent of biodegradation of toluene and *m*-xylene in the acclimated aquifer material were generally similar to those observed in the nonacclimated material. Benzene was recalcitrant in both cases. *o*-Xylene was recalcitrant in the nonacclimated aquifer material, but degradation occurred after toluene addition. In the acclimated aquifer material, *o*-xylene degradation commenced without addition of toluene. Mineralization accounted for 36 to 54% of the total alkylbenzene removal. In general, then, laboratory studies have shown that alkylbenzenes are degraded whereas benzene is recalcitrant when nitrate is used as

the sole electron acceptor. However, these processes are not well understood at field scale, where several other processes, including aerobic biodegradation, can proceed concomitantly.

Several field studies have been performed on nitrate-based bioremediation of fuel-contaminated aquifers. Results include complete removal of benzene and toluene with the xylenes being more recalcitrant (Batterman, 1986), a 95 to 98% reduction in purgeable alkylbenzenes (Sheehan et al, 1988), complete removal of toluene with benzene, ethylbenzene, and the xylenes being unaffected (Lemon et al, 1989), and reductions of 87% , 67%, and 34% for toluene, ethylbenzene, and xylenes, respectively, with benzene being recalcitrant (Hilton et al, 1992). Other field tests are in progress (Hutchins and Wilson, 1994). However, these studies focused on aqueous concentrations and did not address whether BTEX levels were significantly reduced in the aquifer solids. Hutchins et al (1991b) investigated the use of nitrate to promote biological removal of fuel aromatic hydrocarbons for a JP-4 jet fuel spill at Traverse City, Michigan, through a field demonstration project in cooperation with the U.S. Coast Guard. Laboratory tests had indicated that denitrification would be a suitable alternative for bioremediation of the aquifer, although benzene was not degraded (Hutchins et al, 1991b). The field work showed that BTEX was degraded under denitrifying conditions in conjunction with low oxygen (microaerophilic) levels. However, a suitable control site was not available to test the effects of treatment without nitrate addition. Therefore, the relative contribution of nitrate to BTEX biodegradation in the field study requires further clarification.

To further investigate this, Hutchins et al (1992) conducted two column tests using aquifer material to simulate the nitrate field demonstration project carried out earlier at Traverse City, Michigan. The objectives were to better define the effect nitrate addition had on the biodegradation of BTEX in the field study, and to determine whether BTEX removal can be enhanced by supplying a limited amount of oxygen as a supplemental electron acceptor. Columns were operated using limited (0.5-1.5 mg/L) oxygen, limited oxygen plus nitrate, and nitrate alone. In the first column study, benzene was generally recalcitrant compared to the alkylbenzenes, although some removal did occur. The average benzene breakthroughs were $74.3 \pm 5.8\%$, $75.9 \pm 12.1\%$, and $63.1 \pm 9.6\%$ in the columns with limited oxygen, limited oxygen plus nitrate, and nitrate alone, respectively, whereas the corresponding average effluent alkylbenzenes breakthroughs were $22.9 \pm 2.3\%$, $2.9 \pm 1.1\%$, and $4.3 \pm 3.3\%$. In the second column study, nitrate was deleted from the feed to the column originally receiving nitrate alone and added to the feed of the column originally receiving limited oxygen alone. Benzene breakthrough was similar for each column. Breakthrough of alkylbenzenes decreased by an order of magnitude once nitrate was added to the microaerophilic column, whereas alkylbenzene breakthrough increased by 50-fold once nitrate was removed from the denitrifying column. Although the requirement for nitrate to achieve optimum alkylbenzene removal was clearly demonstrated in these columns, there were significant contributions by biotic and abiotic processes other than denitrification which

could not be quantified. Similarly, Anid et al (1993) observed enhanced benzene and alkylbenzene removals in denitrifying columns once low levels of oxygen (<1.0 mg/L) were added, and concluded that processes other than denitrification may have also contributed to the enhanced removal.

C. SCOPE

Research has shown that monoaromatic hydrocarbons, with the possible exception of benzene, can be degraded and in many cases mineralized under denitrifying conditions. In addition, other studies have shown that fuel constituents such as polycyclic aromatic hydrocarbons can be degraded under denitrifying conditions (Mihelcic and Luthy, 1988; Al-Bashir et al, 1990; Bouwer et al, 1992), and the same holds true for aerobic breakdown products of fuel hydrocarbons, such as phenols, alcohols, and aromatic acids (Hu and Shieh, 1987; Dangel et al, 1989; Kuhn et al, 1989; Häggblom et al, 1990; Kluge et al, 1990; Rudolphi et al, 1991; Seyfried et al, 1991; Flyvbjerg et al, 1993). However, these types of compounds will in general be much more readily degraded under aerobic versus denitrifying conditions. Given the problems inherent in promoting aerobic biodegradation of fuel hydrocarbons in anaerobic aquifers, there are significant advantages to using nitrate to supplement rather than replace oxygen for *in situ* bioremediation. Although denitrification has been considered to be an anaerobic process, it is not completely repressed in aerobic soil systems, and in fact low oxygen levels can even promote denitrification (Ottow and Fabig, 1985; Lloyd et al, 1987; Britton, 1989; Patureau et al, 1994; Robertson et al, 1995). From a practical standpoint, several processes can be expected to occur under nitrate-based bioremediation because of the heterogeneity of aquifers and the establishment of microenvironments. In field tests to date, this has complicated the interpretation of the relative benefit of providing nitrate for *in situ* bioremediation.

The objective of this research was to compare the extent of bioremediation using aerobic recharge with and without nitrate addition. Our intent was not to eliminate the other biotic and abiotic processes which might be operating concomitantly with nitrate reduction, but to evaluate the benefit of providing nitrate as a supplemental electron acceptor under field conditions. In addition, this project provided an opportunity to evaluate whether nitrate-based bioremediation would have any effect on native microbial populations or background toxicity.

This report primarily describes RSKERL's efforts, including the site characterization, design, and operation of the pilot system, an interim performance evaluation based on the first 4 months of operation, and a final performance evaluation based on an additional 8 months of operation. In addition, this report describes laboratory microcosm studies which were conducted prior to, during, and after operation of the pilot demonstration system to evaluate the contribution of specific microbial processes. Because this project encompasses the work of several research

efforts to provide a thorough site characterization and performance evaluation of the field project, a complete treatment is beyond the scope of this report. Some of these research efforts have been published separately and will be summarized and referenced in this report where applicable. In addition, the extent of the database for the combined laboratory and field evaluations preclude a thorough treatment of all of the data in this report; therefore, data tables have been included as appendices so that additional information on this project can be obtained as needed.

SECTION II

SITE CHARACTERIZATION

A. SITE DESCRIPTION

Extensive site characterizations by other groups have been published elsewhere and are available (Weston, 1984; EA Engineering, 1987; EA Engineering, 1993). In brief, the field site is located within the Petroleum, Oils, and Lubricants (POL) facility at Eglin Air Force Base, FL (Figure 1). The terrain is relatively flat, with the subsurface consisting of a 30-40 foot thick shallow sand-and-gravel aquifer which extends down to contact the Pensacola Clay confining unit. The aquifer dips to the south-southwest at a rate of 15-25 feet per mile. The estimated porosity is 35-45% and the horizontal and vertical conductivity are approximately 0.5 feet/day (Weston, 1984).

Air Force personnel detected a leak in an underground jet fuel pipeline in April 1984 (Figure 1). A preliminary site characterization estimated that 30,000-40,000 gallons of JP-4 jet fuel had contaminated approximately 4,000 cubic yards of soil and shallow aquifer material. Use of the pipeline was discontinued, and a series of shallow, gravel-filled trenches was installed perpendicular to the direction of fuel movement. By October 1984, skimmer pumps had recovered 7,400 gallons. By 1986, free product had been reduced to levels which were nonrecoverable, and the use of the skimmer pumps was discontinued.

In 1986, EA Engineering conducted additional site characterization to prepare for installation and operation of a pilot demonstration project on enhanced *in situ* biodegradation using hydrogen peroxide (EA Engineering, 1987). A system was designed for delivering nutrients and hydrogen peroxide to the subsurface via three application methods: (1) injection wells, (2) infiltration galleries, and (3) spray infiltration (Figure 2). Four recovery wells were installed to provide ground water for recirculation. The application system was constructed and put into operation in March 1987. Over an 18-month period, approximately 7,800 pounds of inorganic nutrients and 94,000 pounds of 35% hydrogen peroxide were injected into the subsurface. Problems with both hydrogen peroxide stability and loss of infiltration capacity were encountered, which reduced delivery of oxygen to the subsurface (Hinchee et al, 1989). Approximately 5,000 pounds of JP-4 hydrocarbons were removed, with volatilization accounting for approximately 70% of the total removal.

B. RSKERL/RICE/OSU SITE CHARACTERIZATION

Much of the research effort in this project was spent in the initial site characterization. This is because the treatment area for this study encompassed the

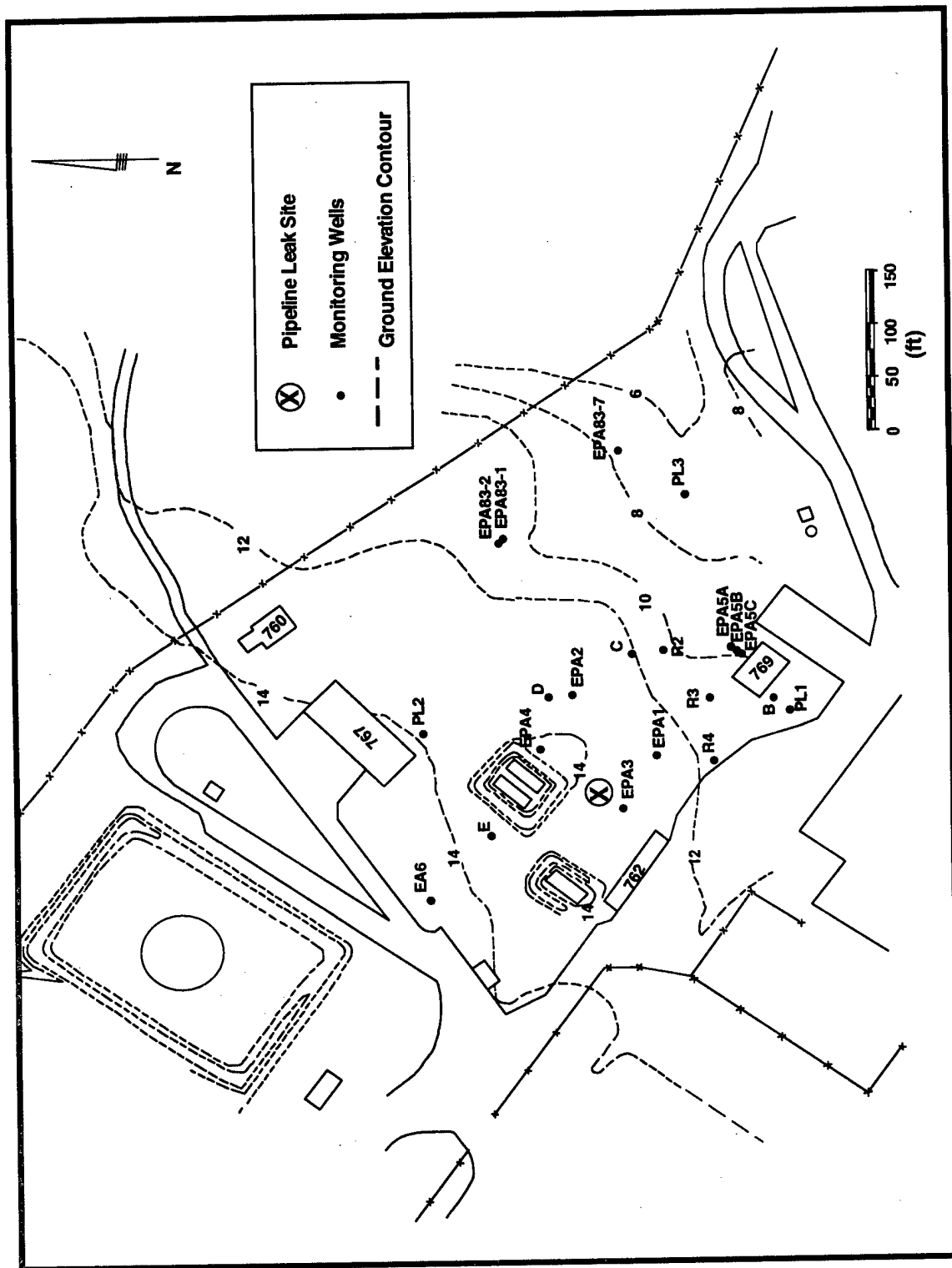


Figure 1. Site Schematic of POL Area at Eglin AFB, Showing Approximate Location of Original Fuel Leak and Ground Elevation Contours.

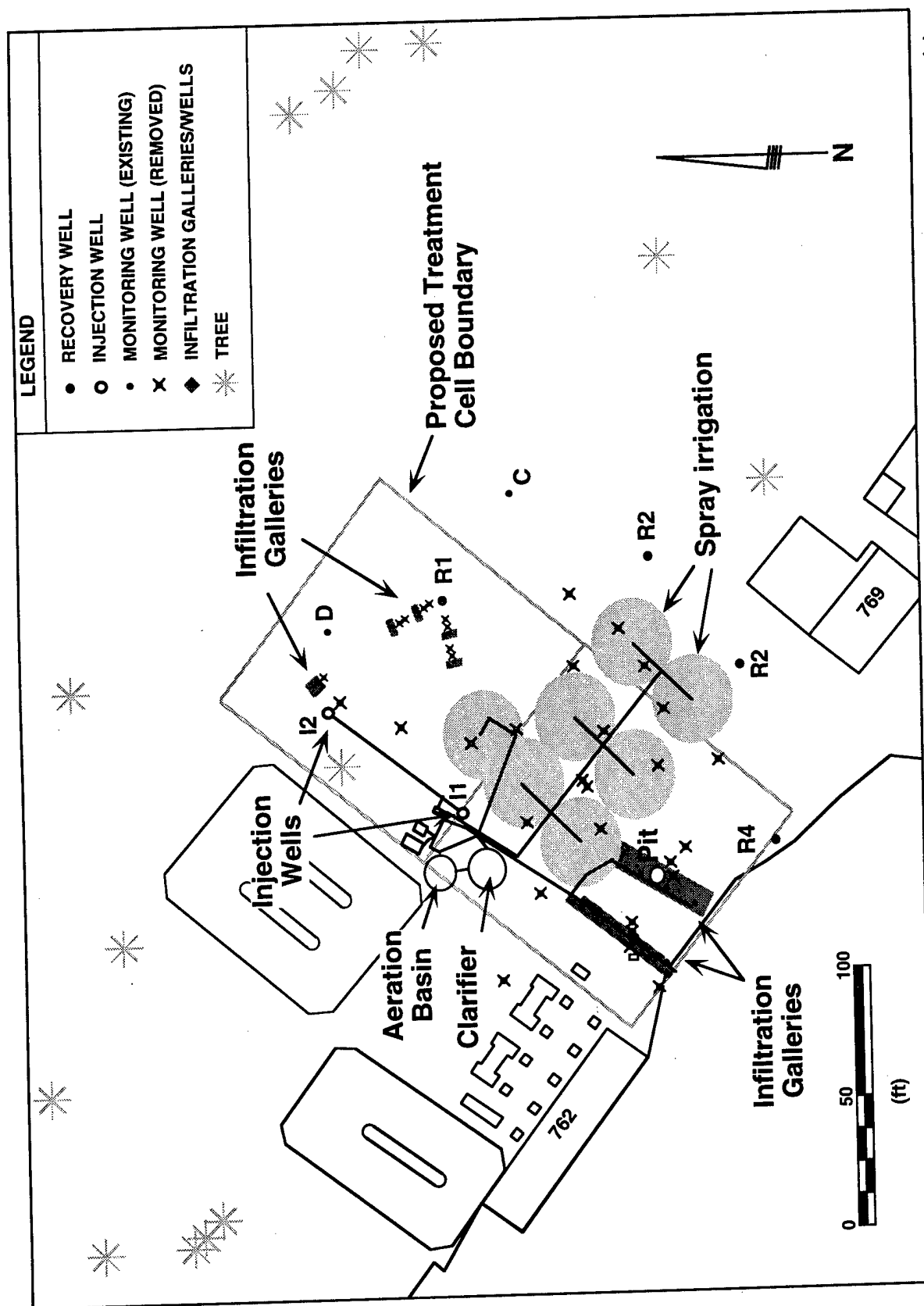


Figure 2. Site Schematic of POL Area at Eglin AFB, Showing Location of Original Hydrogen Peroxide Study and Current Treatment Cell Boundaries.

area affected by the previous hydrogen peroxide study (Figure 2), and operation of the hydrogen peroxide delivery systems undoubtedly had significant effects on the subsurface hydrology, microbiology, and contaminant distribution. In addition, there had been no site characterization for 5 years following the hydrogen peroxide study. Finally, specific parameters required for thorough evaluation of nitrate-based bioremediation were not obtained during previous investigations. Therefore, additional site characterization was required to provide information for design and operation of the nitrate-based pilot demonstration system.

Personnel from the Robert S. Kerr Environmental Research Laboratory (RSKERL), Rice University (Rice), and Oklahoma State University (OSU) coordinated and conducted several field trips to Eglin AFB during 1993-1994. The objectives were to:

- (1) define stratigraphy and hydraulic conductivity using cone penetrometry,
- (2) provide water quality information with respect to both sample depth and aerial coverage,
- (3) obtain continuous core samples through the contaminated interval at several locations across the site to delineate fuel mass and distribution,
- (4) obtain both water and core samples for column studies to assess plugging potential,
- (5) conduct a combined infiltration/tracer test in each proposed treatment cell to evaluate the depth of penetration of the recharge water and develop hydraulic parameters for modeling purposes,
- (6) obtain core samples to evaluate microbial ecology, and
- (7) obtain core samples to evaluate sediment toxicity.

1. Cone Penetrometer Survey

In March 1993, researchers from RSKERL and Rice conducted a comprehensive site investigation at the POL facility to characterize site hydrogeology, determine the spread and vertical extent of BTEX and JP-4 contamination in aquifer core samples, and provide vertical resolution of water quality. This field activity involved the use of a cone penetrometer, geoprobe, and conventional drilling rigs. A cone penetrometer operated by Terra Technologies, Inc., was used to assess areas of BTEX contamination and associated dissolved oxygen as well as to characterize the hydrogeologic properties of the subsurface at the site. Sampling points were installed

at the water table in 26 locations to measure BTEX and dissolved oxygen concentrations across the site (Figure 3). Collected samples were analyzed for BTEX on a real-time basis using a portable GC. This methodology allowed a rapid assessment of the contaminant plume, since collected data could be analyzed and used to delineate additional sampling points. For quality control, 17 split samples were preserved and shipped to RSKERL for GC/MSD analysis. With the exception of two anomalous readings (CPT-8, CPT-9), laboratory and field analytical results agreed quite well ($r^2 = 0.9986$). The anomalous data were not used. A maximum BTEX level of 4,500 $\mu\text{g/L}$ was detected, with levels decreasing to approximately 10 $\mu\text{g/L}$ over a distance of 300 feet downgradient of the spill (Figure 3). Lateral spreading of the plume was identified over a distance of 350 feet. Dissolved oxygen levels measured in the field were consistently below 1 mg/L across the investigated area.

The detailed stratigraphy provided by the cone typically identified sand from the ground surface to the depth of penetration (15-20 feet). Clay lenses were detected at about 15 feet in several locations. One cone hole (CPT-14) was completed to a depth of 33 feet where a clay aquitard identified by previous investigators was encountered. Water table elevations determined by the cone penetrometer provided data for a potentiometric map, indicating that the ground water flow generally follows land surface contours as shown in Figure 1. Interpretation of the cone logs suggests that the conductivity of the sand ranges from 0.010-0.045 cm/sec.

2. Water Quality Analyses

a. Methods

Several parameters were monitored to provide an extensive characterization of water quality and indicate the types of microbial processes that may have been occurring in the subsurface. Because the water table was very shallow, samples were collected using either peristaltic pumps or submersible pumps. Flow-through systems were used to minimize contact with air so that samples could be analyzed in the field for dissolved oxygen (DO) and pH using electrodes. In addition, samples were analyzed immediately for soluble iron using a Chemetrics® photometric method. Duplicate samples were taken for BTEX and TOC by filling 40-mL VOA bottles and acidifying to $\text{pH} < 2$ with H_2SO_4 . These were sealed without headspace using Teflon-lined septa. Duplicate samples were also taken for dissolved gases by overfilling 60-mL glass serum bottles, acidifying to $\text{pH} < 2$ with H_2SO_4 , and crimp-sealing without headspace using Teflon®-lined grey butyl rubber septa. Samples for nutrients and inorganic parameters were collected in clean plastic containers. All samples were refrigerated and/or stored on ice for transport to RSKERL.

To evaluate volatile aromatic hydrocarbons, samples were analyzed for trimethylbenzenes as well as BTEX. The trimethylbenzenes include mesitylene

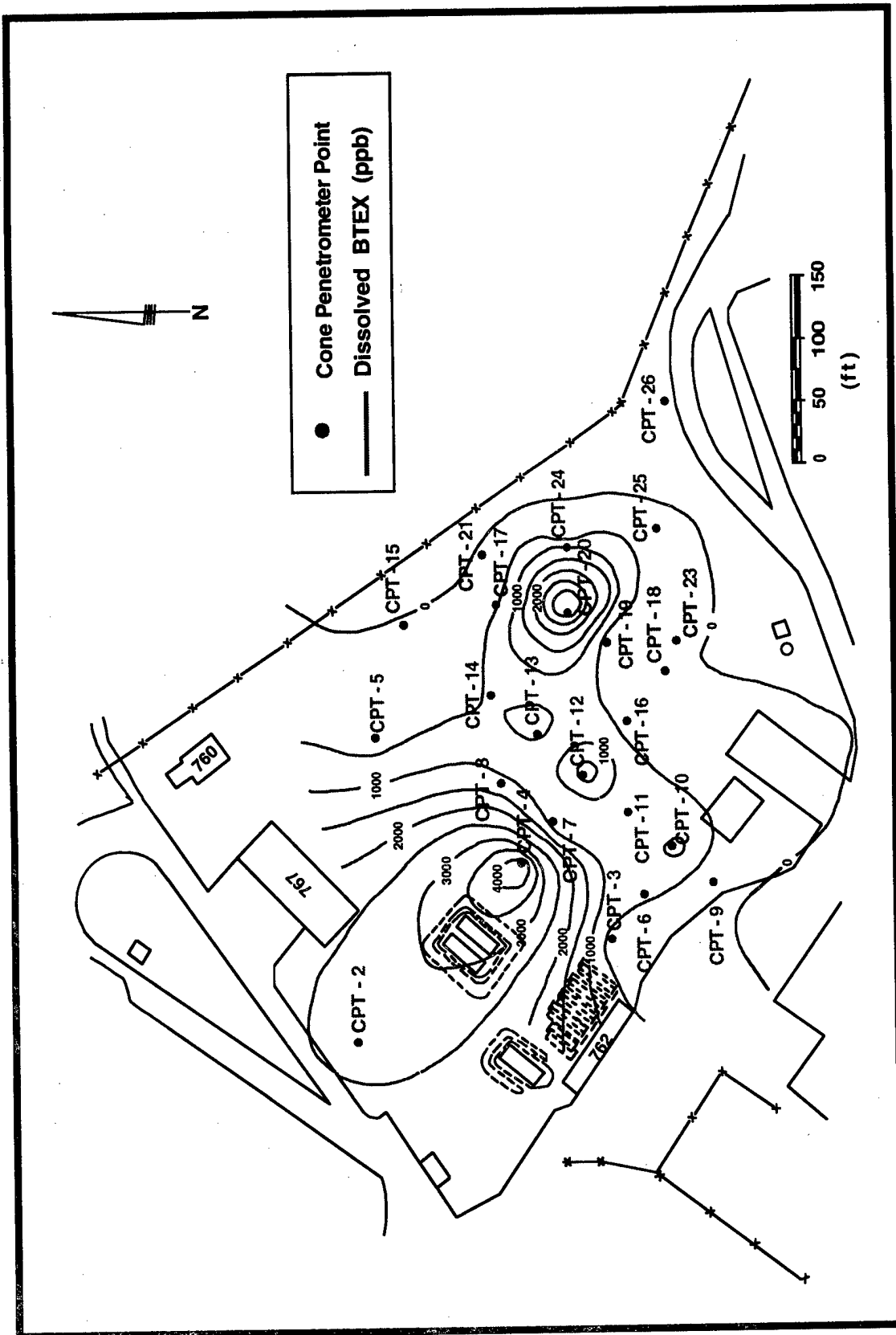


Figure 3. Cone Penetrometer Sample Locations and Aqueous BTEX Levels for Mar 93 Site Characterization, Prior to Pilot Project Operation. Samples Taken at Water Table, 2 to 5 Feet Below Ground Surface.

(MESIT), pseudocumene (PSCU), and 1,2,3-trimethylbenzene (TMB). Taken collectively, this combination will be referred to as BTEXTMB for the purposes of this report. Samples were analyzed using a Varian Saturn II Mass Spectrometer in combination with a Varian 3400 Gas Chromatograph and a Tekmar 7000 Headspace Autoanalyzer. The mass spectrometer was tuned to meet EPA Method 524.2 mass spectrometer tune criteria for bromofluorobenzene spectrum. It was operated at 2 scans/sec over a mass range of 45 to 250 amu. Other settings were as follows: acquire time = 13 min; emission current = 20 μ A; electron multiplier = 1400 volts; filament and multiplier delay = 90 sec; peak threshold = 2; ion time = 100 μ sec; mass defect = -50 mmu/100 amu; and background mass = 45 amu. The tune parameters were: Segment 1 = 110; Segment 2 = 70; Segment 3 = 100; and Segment 4 = 90. The gas chromatograph injector temperature was 175°C, and the transfer line temperature was 200°C. A 30-m, 0.25-mm DB-Wax capillary column with 0.5- μ m film thickness was temperature programmed from 45°C (2.0 minutes) to 131°C at 8°C/minute, then to 225°C at 30°C/minute. The column flow rate was 1 mL/minute, and the split flow was 30 mL/minute. The headspace autoanalyzer settings were as follows: platen = 85°C; sample equilibration = 30 minutes; sample loop = 1 mL; and the valve = 150°C. An internal standard calibration method was established for each compound using concentrations of 1.0, 5.0, 10.0, 50.0, 100, 500, and 1000 μ g/L. The method detection limit was 0.1 μ g/L.

Dissolved gases were analyzed by replacing part of the water volume in the sealed serum bottles with helium and then sampling the equilibrated headspace (Kampbell et al, 1989). Methane was analyzed using a Hewlett-Packard 5890 gas chromatograph with a thermal conductivity detector. Gases were chromatographed using a 6-foot CTR I dual column consisting of an 1/8-inch inner column packed with Poropak mix and a 1/4-inch outer column packed with activated Molecular Sieve (Alltech Associates, Deerfield, IL). Operation was isothermal at 35°C with a helium flow rate of 29 mL/minute. Nitrous oxide was analyzed using a Hewlett-Packard 5890 gas chromatograph with an electron capture detector and a 6-foot x 1/8-inch stainless steel column filled with 100/120 mesh Poropak Q (Supelco, Bellefonte, PA). The column was temperature programmed from 55°C (1.0 minute) to 140°C (5.0 minutes) at 20°C/minute. The carrier gas was 95% argon/5% methane at 30 mL/min. Aqueous dissolved gas concentrations were calculated for the original solutions using Henry's constants and correcting for total mass in gas and liquid phases. Based on the sampled volumes, detection limits were 0.07 and 0.0004 mg/L for methane and nitrous oxide, respectively.

Bromide, chloride, sulfate, and occasionally thiosulfate were analyzed using a Quanta 4000 (Waters) capillary electrophoresis unit. The electrolyte was 0.14 M chromate with CIA-Pak OFM Anion-BT solution (Waters). Separation was done on a 60 cm x 75 μ m fused silica column under a 20 KV negative voltage with a current of 16 μ amp, and analytes were detected with a UV detector at 254 nm. Samples were also analyzed for aqueous nitrate, nitrite, ammonia, phosphate, and total organic carbon

(TOC) according to standard EPA methods (Kopp and McKee, 1979).

b. Monitoring Wells

There are several wells located at the POL area which had been installed over the past 10 years. However, well logs and construction records could not be found for some of these. In addition, most of the existing wells are screened over large intervals, which provides little information on water quality in localized zones of contamination. Because of this, many of the wells at the site were not used in this study. Also, additional wells were constructed during site characterization as part of this and other ongoing investigations. Those wells shown in Figure 1 were periodically sampled to provide background information and to assess the effects of pilot operation outside of the treatment cells. Details of well construction are shown in Table 1. Water quality analyses for the monitoring wells at different time periods are shown in Table 2. Because EPA Wells 1-4, 5B, 5C, 83-1, 83-2, and 83-7 were installed after the initial sampling trip, background water quality data were not available for these locations. This discussion focuses on the 1993 data for the original site characterization; the remaining data in Table 2 will be discussed in later sections. The data indicate the general anaerobic nature of the aquifer, with pH values generally less than 6.5, dissolved oxygen less than 1.0 mg/L, and methane concentrations up to 15 mg/L. The lower zones of the aquifer, contacted by the PL wells, appeared to be somewhat less anaerobic, with lower methane concentrations, higher sulfate levels, and less contamination. However, significant concentrations of BTEXTMB were present throughout the aquifer, especially in the vicinity of the original treatment area (Table 2, Figure 1). Benzene concentrations were reduced relative to the other constituents, probably as a result of both weathering and operation of the pilot project on hydrogen peroxide treatment. However, concentrations exceeded compliance levels in several locations. Also, *o*-xylene levels were similarly reduced, presumably because this dimethylbenzene isomer is more labile than its analogues under anaerobic conditions. Very little nitrate was originally present, but nutrients such as ammonia-nitrogen and phosphate were relatively high, especially in the original treatment area. These data showed that the overall aquifer was still contaminated, and that the subsurface might be conducive to nitrate-based bioremediation.

c. Geoprobe Samples

Although the data provided by the monitoring wells gave a general picture of the state of the aquifer, there was insufficient vertical resolution to ascertain the water quality status in the proposed treatment area. RSKERL researchers therefore used a geoprobe to drive a screened rod to three selected depths at several locations to obtain water samples for correlating water quality information with core analyses. Locations of the geoprobe sample points are shown in Figure 4, and the water quality data are shown in Table 3.

TABLE 1. WELL CONSTRUCTION DATA FOR EGLIN AFB SITE

Well	Casing Diameter (in)	Elevation of ground surface (ft MSL)	Elevation of TOC (ft MSL)	Stick-up (ft)	Depth to Bottom (ft from G.S.)	Screened Interval (ft from G.S.)	Screen Length (ft)	Grouted Interval (ft from G.S.)
EPA1	2.0	11.92	13.97	2.05	11.00	1.0 - 11.0	10.0	0.0 - 1.0
EPA2	2.0	12.79	14.80	2.01	11.00	1.0 - 11.0	10.0	0.0 - 1.0
EPA3	2.0	12.93	14.89	1.96	11.00	1.0 - 11.0	10.0	0.0 - 3.0
EPA4	2.0	13.75	15.69	1.94	11.00	1.0 - 11.0	10.0	0.0 - 3.0
EPA5A	2.0	8.66	10.62	1.97	11.00	1.0 - 11.0	10.0	0.0 - 3.0
EPA5B	2.0	8.66	10.71	2.05	21.00	11.0 - 21.0	10.0	0.0 - 3.0
EPA5C	2.0	8.66	10.61	1.95	31.00	21.0 - 31.0	10.0	0.0 - 3.0
EPA83-1	2.0	10.35	12.84	2.49	26.00	20.2 - 25.2	5.0	0.0 - 19.0
EPA83-2	2.0	10.46	12.77	2.31	8.00	2.3 - 7.3	5.0	0.0 - 2.0
EPA83-7	2.0	8.72	10.68	1.96	9.10	3.4 - 8.4	5.0	0.0 - 2.5
PL1	2.0	10.51	12.51	2.00	50.50	? - 50	-	-
PL2	2.0	13.35	15.49	2.14	49.50	? - 50	-	-
PL3	2.0	6.83	8.94	2.11	39.19	? - 40	-	-
R2	6.0	9.78	10.40	0.62	18.50	8.5 - 13.0	4.5	0.0 - 3.0
R3	6.0	10.23	10.90	0.67	18.50	8.5 - 13.0	4.5	0.0 - 3.0
R4	6.0	11.40	11.86	0.46	18.50	8.5 - 13.0	4.5	0.0 - 3.0
B	2.0	10.55	12.14	1.59	13.16	1 - 13?	13?	0?
C	2.0	11.54	13.76	2.22	14.65	1 - 13?	13?	0?
D	2.0	13.16	15.47	2.31	14.47	1 - 13?	13?	0?
E	2.0	13.76	16.10	2.34	14.49	1 - 13?	13?	0?
EA6	2.0	13.91	16.42	2.51	7.91	2.9 - 7.9	5.0	-

TABLE 2. PERIODIC WATER QUALITY ANALYSES FOR POL WELLS

Well	Date	Water Level (ft from TOC)	pH (pH units)	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	TOC (mg/L)	CH ₄ (mg/L)	N ₂ O (mg/L)
EPA1	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA1	8/23/94	4.34	6.07	<0.1	4.1	1.6	11.6	0.79	<0.05	1.47	0.99	5.6	NA	NA	NA
EPA1	5/27/95	5.00	6.90	0.3	NA	<0.5	10.3	0.51	<0.05	1.55	0.93	3.6	8.3	0.29	<0.001
EPA1	4/20/96	4.28	6.69	0.2	<0.1	<0.5	4.9	<0.05	<0.05	1.46	0.87	4.0	11.8	10.50	<0.001
EPA2	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA2	8/23/94	5.19	6.00	<0.1	2.0	1.1	9.9	<0.05	<0.05	0.49	<0.05	3.4	NA	NA	NA
EPA2	5/27/95	5.91	6.90	0.3	NA	<0.5	9.7	<0.05	<0.05	0.49	<0.05	5.4	4.0	0.63	<0.001
EPA2	4/20/96	5.15	6.35	<0.1	<0.1	<0.5	12.8	<0.05	<0.05	0.24	<0.05	13.0	4.7	8.51	0.004
EPA3	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA3	8/23/94	5.02	5.68	<0.1	3.9	5.9	8.9	<0.05	<0.05	1.86	<0.05	<0.5	NA	NA	NA
EPA3	5/27/95	5.81	6.46	0.3	NA	1.2	6.9	<0.05	<0.05	4.02	<0.05	<0.5	31.3	7.59	<0.001
EPA3	4/20/96	5.00	6.04	<0.1	<0.1	<0.5	10.1	<0.05	<0.05	2.42	<0.05	3.5	16.2	14.50	<0.001
EPA4	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA4	8/23/94	5.93	5.80	<0.1	6.5	1.2	4.8	0.29	<0.05	1.77	<0.05	2.9	NA	NA	NA
EPA4	5/27/95	6.68	6.84	0.2	NA	<0.5	8.6	<0.05	<0.05	0.20	<0.05	<0.5	4.3	1.12	<0.001
EPA4	4/20/96	5.90	6.16	<0.1	<0.1	<0.5	13.5	<0.05	<0.05	0.60	<0.05	<0.5	5.4	9.81	0.009
EPA5A	2/24/93	3.77	6.15	0.6	7.4	<0.5	4.5	<0.05	<0.05	1.79	0.18	9.2	32.3	9.16	NA
EPA5A	8/23/94	3.11	5.74	<0.1	4.8	7.6	6.3	<0.05	<0.05	2.77	0.24	1.1	NA	NA	NA
EPA5A	5/27/95	3.63	6.22	0.3	NA	<0.5	4.6	<0.05	<0.05	1.75	0.11	2.0	25.8	3.97	<0.001
EPA5A	4/20/96	2.89	6.40	<0.1	<0.1	<0.5	8.7	<0.05	<0.05	0.82	0.07	6.3	14.8	6.88	<0.001
EPA5B	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA5B	8/23/94	3.33	5.77	<0.1	11.6	8.9	6.0	<0.05	<0.05	3.41	0.10	1.0	NA	NA	NA
EPA5B	5/27/95	3.89	6.28	0.3	NA	<0.5	7.2	<0.05	<0.05	3.54	0.18	1.1	12.5	3.47	<0.001
EPA5B	4/20/96	3.20	6.41	<0.1	<0.1	<0.5	16.3	<0.05	<0.05	2.22	0.16	<0.5	20.6	16.50	<0.001
EPA5C	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA5C	8/23/94	3.25	6.08	<0.1	18.7	7.4	4.9	<0.05	<0.05	0.63	<0.05	3.3	NA	NA	NA
EPA5C	5/27/95	3.81	6.62	0.2	NA	3.2	7.6	<0.05	<0.05	1.40	<0.05	2.5	4.8	1.10	<0.001
EPA5C	4/20/96	3.11	6.40	<0.1	1.3	<0.5	5.7	<0.05	<0.05	1.80	<0.05	4.7	4.6	1.97	<0.001

TABLE 2 (cont). PERIODIC WATER QUALITY ANALYSES FOR POL WELLS

Well	Date	Water Level (ft from TOC)	pH (pH units)	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	TOC (mg/L)	CH ₄ (mg/L)	N ₂ O (mg/L)
EPA83-1	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA83-1	8/27/94	7.42	5.94	0.9	7.1	1.2	20.0	<0.05	<0.05	1.10	0.10	<0.5	5.6	2.65	<0.001
EPA83-1	5/26/95	7.54	6.35	0.4	NA	<0.5	8.2	<0.05	<0.05	0.79	0.26	2.1	3.7	1.54	<0.001
EPA83-1	4/19/96	7.17	6.41	<0.1	<0.1	<0.5	8.6	<0.05	<0.05	0.84	0.14	<0.5	6.1	10.30	<0.001
EPA83-2	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA83-2	8/27/94	4.11	6.40	0.8	2.0	<0.5	10.1	<0.05	<0.05	0.84	<0.05	<0.5	9.0	10.70	<0.001
EPA83-2	5/26/95	4.38	6.39	0.4	NA	<0.5	6.6	<0.05	<0.05	0.35	<0.05	1.0	6.8	7.43	<0.001
EPA83-2	4/19/96	3.68	6.57	<0.1	<0.1	<0.5	4.5	<0.05	<0.05	0.39	<0.05	3.0	6.2	12.10	<0.001
EPA83-7	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA83-7	8/27/94	5.62	4.97	1.0	2.1	1.4	6.6	<0.05	<0.05	0.78	<0.05	1.0	7.4	9.78	<0.001
EPA83-7	5/26/97	5.71	5.15	1.7	NA	<0.5	2.5	<0.05	<0.05	1.54	0.19	2.3	12.8	8.90	<0.001
EPA83-7	4/20/96	4.77	5.74	0.6	<0.1	<0.5	2.6	<0.05	<0.05	0.40	0.34	6.1	4.7	9.52	0.004
PL1	2/24/93	5.24	6.64	1.1	4.6	<0.5	8.7	<0.05	<0.05	0.28	0.15	25.3	3.6	0.62	NA
PL1	8/27/94	4.92	6.25	3.1	10.9	2.8	6.1	0.06	<0.05	0.99	<0.05	6.9	5.0	2.10	<0.001
PL1	5/27/95	5.21	6.55	NA	NA	2.8	7.1	<0.05	<0.05	0.80	0.07	4.1	3.8	3.35	<0.001
PL1	4/20/96	4.55	6.45	2.5	0.1	<0.5	9.7	<0.05	<0.05	0.42	<0.05	6.1	3.4	0.83	<0.001
PL2	2/24/93	6.54	6.35	1.0	2.9	<0.5	11.3	0.37	<0.05	0.08	<0.05	31.2	4.3	4.71	NA
PL2	8/28/94	6.35	5.62	1.6	1.4	1.1	4.4	0.06	<0.05	<0.05	<0.05	14.5	1.4	0.18	<0.001
PL2	5/26/95	6.59	5.80	0.5	NA	<0.5	3.8	<0.05	<0.05	0.21	<0.05	7.2	2.8	1.59	<0.001
PL2	4/20/96	5.97	5.95	<0.1	<0.1	<0.5	3.1	<0.05	<0.05	0.10	<0.05	13.5	1.7	0.25	0.004
PL3	2/24/93	4.50	6.70	1.0	14.5	<0.5	6.2	0.18	<0.05	0.92	0.10	6.0	3.8	1.13	NA
PL3	8/27/94	4.17	6.23	0.7	8.0	<0.5	4.4	0.06	<0.05	0.35	<0.05	2.0	4.2	1.90	<0.001
PL3	5/26/95	4.18	6.10	0.5	NA	0.9	9.5	<0.05	<0.05	0.77	0.08	1.1	3.1	1.49	<0.001
PL3	4/20/96	3.74	6.41	<0.1	0.2	<0.5	5.5	<0.05	<0.05	1.03	<0.05	2.5	4.5	2.55	<0.001
R2	3/22/93	1.98	6.10	<0.1	NA	1.4	2.0	0.08	<0.05	3.44	0.88	1.5	31.0	15.30	ND
R2	8/27/94	1.77	6.09	0.4	4.6	10.9	19.3	<0.05	<0.05	2.78	0.20	<0.5	11.2	3.77	<0.001
R2	5/26/95	2.03	6.31	0.4	NA	<0.5	7.5	<0.05	<0.05	3.06	0.57	5.9	6.0	2.71	<0.001
R2	4/20/96	1.27	6.45	<0.1	<0.1	<0.5	25.3	<0.05	<0.05	2.34	0.48	1.9	15.4	12.10	<0.001

TABLE 2 (cont). PERIODIC WATER QUALITY ANALYSES FOR POL WELLS

Well	Date	Water Level (ft from TOC)	pH (pH units)	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	TOC (mg/L)	CH ₄ (mg/L)	N ₂ O (mg/L)
R3	3/22/93	3.40	6.00	0.2	NA	2.6	1.7	<0.05	<0.05	2.80	0.24	1.9	30.7	6.64	ND
R3	8/27/94	3.17	6.21	0.9	17.1	16.2	8.2	0.06	<0.05	2.64	0.18	<0.5	12.9	4.09	<0.001
R3	5/27/95	3.40	6.62	0.2	NA	<0.5	7.6	<0.05	<0.05	2.51	0.44	11.2	5.4	0.85	<0.001
R3	4/19/96	2.65	6.60	<0.1	<0.1	<0.5	9.4	<0.05	<0.05	1.66	0.55	5.7	10.0	5.22	<0.001
R4	3/24/93	3.30	6.30	0.3	NA	2.1	6.1	<0.05	<0.05	0.84	0.52	8.2	3.9	0.65	ND
R4	8/27/94	2.90	5.96	1.0	15.2	17.5	9.1	<0.05	<0.05	3.13	0.61	4.1	10.5	1.86	<0.001
R4	5/27/95	3.20	6.83	0.2	NA	<0.5	8.4	2.49	0.14	1.52	<0.05	10.8	4.4	0.14	0.419
R4	4/19/96	2.44	6.63	<0.1	0.1	<0.5	7.9	<0.05	<0.05	3.13	0.48	0.9	10.2	5.48	<0.001
B	2/24/93	4.58	6.54	0.6	9.2	<0.5	3.5	<0.05	<0.05	0.60	0.26	2.5	7.1	4.65	NA
B	8/27/94	4.29	6.18	1.0	12.3	3.1	9.3	<0.05	<0.05	2.77	0.22	<0.5	16.7	6.57	<0.001
B	5/27/95	4.48	6.54	0.2	NA	<0.5	7.2	<0.05	<0.05	1.44	0.30	<0.5	9.5	5.51	<0.001
B	4/20/96	3.84	6.50	<0.1	<0.1	<0.5	11.0	<0.05	<0.05	0.58	0.30	1.8	4.5	2.49	<0.001
C	2/24/93	4.90	6.01	0.8	5.3	<0.5	<0.5	0.16	<0.05	1.95	0.25	<0.5	24.1	8.51	NA
C	8/27/94	4.68	6.24	1.0	5.2	<0.5	11.9	<0.05	<0.05	0.54	0.09	<0.5	17.2	1.44	<0.001
C	5/26/95	4.97	6.65	0.5	NA	<0.5	9.4	<0.05	<0.05	0.47	0.07	<0.5	4.1	1.00	<0.001
C	4/20/96	4.26	6.40	0.1	<0.1	<0.5	18.6	<0.05	<0.05	1.02	0.10	5.7	10.5	9.09	<0.001
D	2/24/93	6.44	6.26	0.8	8.6	<0.5	11.3	0.17	<0.05	0.75	0.35	9.8	10.7	7.25	NA
D	8/28/94	6.31	6.34	1.2	2.2	<0.5	11.0	0.06	<0.05	0.17	0.20	1.0	9.8	1.52	0.001
D	5/26/95	6.56	6.58	0.5	NA	<0.5	9.6	<0.05	<0.05	0.19	0.36	<0.5	2.5	2.97	<0.001
D	4/20/96	5.82	6.30	0.1	<0.1	<0.5	7.7	<0.05	<0.05	0.37	0.21	6.9	5.3	9.26	<0.001
E	2/24/93	6.52	6.17	1.3	4.3	<0.5	2.2	0.20	<0.05	0.45	0.13	4.5	6.2	NA	NA
E	8/28/94	6.33	6.05	0.5	2.3	<0.5	3.9	<0.05	<0.05	0.21	<0.05	<0.5	8.2	9.32	<0.001
E	5/27/95	6.68	6.20	0.3	NA	<0.5	2.2	<0.05	<0.05	0.29	<0.05	<0.5	6.9	8.31	<0.001
E	4/20/96	5.87	6.35	<0.1	<0.1	<0.5	15.0	<0.05	<0.05	0.28	<0.05	2.4	6.3	13.00	<0.001
EA6	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EA6	8/28/94	6.30	5.96	0.4	1.8	<0.5	1.5	<0.05	<0.05	0.24	<0.05	<0.5	5.0	7.43	<0.001
EA6	5/27/95	6.70	6.00	0.2	NA	<0.5	2.4	<0.05	<0.05	<0.05	0.07	<0.5	4.8	7.02	<0.001
EA6	4/20/96	5.92	6.13	<0.1	<0.1	<0.5	4.5	<0.05	<0.05	0.10	<0.05	14.5	3.4	5.65	0.065

TABLE 2 (cont). PERIODIC WATER QUALITY ANALYSES FOR POL WELLS

Well	Date	Water Level (ft from TOC)	BZ (µg/L)	TOL (µg/L)	ETBZ (µg/L)	PXYL (µg/L)	MXYL (µg/L)	OXYL (µg/L)	MESIT (µg/L)	PSCU (µg/L)	TMB (µg/L)	BTEXTMB (µg/L)
EPA1	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA1	8/23/94	4.34	<1.0	<1.0	1.0	1.0	1.2	1.0	<1.0	1.0	1.2	6
EPA1	5/27/95	5.00	<1.0	17.5	10.4	20.7	34.2	27.8	12.9	78.9	21.9	224
EPA1	4/20/96	4.28	5.4	<1.0	9.7	4.5	3.0	<1.0	7.7	103.0	37.2	171
EPA2	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA2	8/23/94	5.19	<1.0	1.0	1.3	4.2	5.3	5.7	116.0	83.8	70.6	288
EPA2	5/27/95	5.91	<1.0	<1.0	<1.0	1.0	2.4	<1.0	58.4	20.4	18.0	100
EPA2	4/20/96	5.15	<1.0	<1.0	19.0	51.0	73.4	<1.0	132.0	176.0	139.0	590
EPA3	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA3	8/23/94	5.02	19.4	2100.0	777.0	855.0	2120.0	899.0	93.7	306.0	166.0	7340
EPA3	5/27/95	5.81	10.3	579.0	290.0	297.0	651.0	380.0	67.2	153.0	102.0	2530
EPA3	4/20/96	5.00	2.7	305.0	685.0	786.0	1750.0	551.0	138.0	569.0	189.0	4976
EPA4	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA4	8/23/94	5.93	24.5	5410.0	1460.0	2370.0	5640.0	4140.0	443.0	1610.0	509.0	21600
EPA4	5/27/95	6.68	7.5	2070.0	741.0	1160.0	2140.0	2030.0	366.0	944.0	481.0	9940
EPA4	4/20/96	5.90	17.3	1570.0	827.0	1290.0	3450.0	2110.0	386.0	1240.0	404.0	11294
EPA5A	2/24/93	3.77	8.3	2.8	11.7	42.0	80.0	52.4	25.7	47.5	34.6	305
EPA5A	8/23/94	3.11	1.5	5.4	9.7	42.0	52.3	1.0	16.6	46.0	20.3	195
EPA5A	5/27/95	3.63	<1.0	<1.0	6.9	21.3	24.8	<1.0	22.1	77.1	32.9	185
EPA5A	4/20/96	2.89	<1.0	<1.0	4.7	19.0	33.9	<1.0	25.1	56.6	35.7	175
EPA5B	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA5B	8/23/94	3.33	22.7	1.6	18.6	26.2	43.1	1.0	15.1	204.0	16.1	348
EPA5B	5/27/95	3.89	<1.0	<1.0	3.2	8.2	3.4	<1.0	5.0	73.0	4.9	98
EPA5B	4/20/96	3.20	10.1	<1.0	6.1	12.4	6.7	<1.0	1.8	17.4	7.4	62
EPA5C	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA5C	8/23/94	3.25	6.2	1.0	41.7	77.6	53.4	76.5	9.1	78.7	17.6	362
EPA5C	5/27/95	3.81	<1.0	<1.0	1.1	3.5	1.8	<1.0	2.7	16.7	2.4	28
EPA5C	4/20/96	3.11	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1

TABLE 2 (cont). PERIODIC WATER QUALITY ANALYSES FOR POL WELLS

Well	Date	Water Level (ft from TOC)	BZ (µg/L)	TOL (µg/L)	ETBZ (µg/L)	PXYL (µg/L)	MXYL (µg/L)	OXYL (µg/L)	MESIT (µg/L)	PSCU (µg/L)	TMB (µg/L)	BTEXTMB (µg/L)
EPA83-1	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA83-1	8/27/94	7.42	2.2	1.0	7.0	12.6	15.1	1.0	16.6	115.0	15.2	186
EPA83-1	5/26/95	7.54	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	6.6	1.4	9
EPA83-1	4/19/96	7.17	4.4	2.2	34.6	31.0	134.0	1.8	21.1	36.0	13.2	278
EPA83-2	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA83-2	8/27/94	4.11	16.1	22.0	4.7	31.0	53.9	57.8	26.5	51.0	24.2	287
EPA83-2	5/26/95	4.38	8.8	1.6	3.7	21.6	39.9	2.3	20.1	34.9	16.7	150
EPA83-2	4/19/96	3.68	43.1	1.2	7.3	41.6	37.9	<1.0	45.3	70.3	27.6	274
EPA83-7	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EPA83-7	8/27/94	5.62	1.6	1.7	1.0	3.1	6.9	4.5	11.0	22.9	13.2	66
EPA83-7	5/26/97	5.71	6.2	<1.0	3.0	6.0	15.7	7.8	39.9	82.6	46.3	208
EPA83-7	4/20/96	4.77	2.3	<1.0	<1.0	1.7	4.4	2.5	13.6	24.9	15.7	65
PL1	2/24/93	5.24	6.1	<1.0	2.7	1.9	1.7	<1.0	<1.0	1.1	<1.0	14
PL1	8/27/94	4.92	23.1	1.0	61.0	108.0	33.3	1.0	7.3	66.2	29.0	330
PL1	5/27/95	5.21	12.2	<1.0	19.5	95.7	73.4	<1.0	16.9	121.0	16.2	355
PL1	4/20/96	4.55	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
PL2	2/24/93	6.54	34.2	<1.0	5.4	50.9	263.0	1.3	22.1	62.1	35.7	476
PL2	8/28/94	6.35	<1.0	<1.0	<1.0	1.0	<1.0	<1.0	<1.0	1.6	<1.0	3
PL2	5/26/95	6.59	<1.0	1.0	75.0	36.0	5.0	1.7	<1.0	25.8	<1.0	145
PL2	4/20/96	5.97	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
PL3	2/24/93	4.50	<1.0	<1.0	1.3	2.4	5.1	1.5	1.0	10.3	1.8	23
PL3	8/27/94	4.17	<1.0	<1.0	1.0	4.2	4.3	1.0	2.3	20.9	5.1	39
PL3	5/26/95	4.18	<1.0	<1.0	4.0	<1.0	9.0	<1.0	11.8	80.4	5.4	111
PL3	4/20/96	3.74	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	4.9	<1.0	5
R2	3/22/93	1.98	3.6	10.7	152.0	107.0	201.0	34.3	30.9	360.0	47.2	947
R2	8/27/94	1.77	1.0	<1.0	8.3	9.3	6.4	7.9	16.7	156.0	24.8	230
R2	5/26/95	2.03	<1.0	<1.0	5.1	2.9	4.0	<1.0	8.3	77.9	3.1	101
R2	4/20/96	1.27	<1.0	<1.0	13.6	5.0	5.4	<1.0	4.8	55.0	3.9	88

TABLE 2 (cont). PERIODIC WATER QUALITY ANALYSES FOR POL WELLS

Well	Date	Water Level (ft from TOC)	BZ (µg/L)	TOL (µg/L)	ETBZ (µg/L)	PXYL (µg/L)	MXYL (µg/L)	OXYL (µg/L)	MESIT (µg/L)	PSCU (µg/L)	TMB (µg/L)	BTEXTMB (µg/L)
R3	3/22/93	3.40	6.3	2.5	43.0	86.4	132.0	3.9	32.5	103.0	51.4	461
R3	8/27/94	3.17	5.4	1.4	60.5	126.0	158.0	115.0	63.4	236.0	89.9	856
R3	5/27/95	3.40	<1.0	<1.0	4.4	6.1	1.4	<1.0	3.3	28.2	7.7	51
R3	4/19/96	2.65	1.0	<1.0	2.7	7.5	12.7	<1.0	2.6	36.1	4.9	68
R4	3/24/93	3.30	<1.0	<1.0	<1.0	<1.0	2.3	<1.0	<1.0	<1.0	<1.0	2
R4	8/27/94	2.90	2.9	<1.0	9.9	20.3	26.1	19.2	17.5	69.0	43.8	209
R4	5/27/95	3.20	<1.0	<1.0	<1.0	1.5	<1.0	<1.0	1.1	7.0	2.6	12
R4	4/19/96	2.44	3.0	<1.0	10.6	3.3	1.9	<1.0	<1.0	23.7	3.3	46
B	2/24/93	4.58	28.0	1.2	3.5	9.0	13.4	1.0	1.1	13.3	1.0	72
B	8/27/94	4.29	104.0	2.6	301.0	594.0	259.0	7.7	99.3	517.0	146.0	2030
B	5/27/95	4.48	60.1	<1.0	165.0	160.0	58.5	3.3	74.0	554.0	46.2	1121
B	4/20/96	3.84	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	4.9	<1.0	5
C	2/24/93	4.90	<1.0	24.3	147.0	285.0	654.0	146.0	140.0	327.0	181.0	1900
C	8/27/94	4.68	<1.0	3.4	10.0	47.8	74.1	141.0	179.0	285.0	217.0	957
C	5/26/95	4.97	<1.0	<1.0	1.7	4.6	7.3	13.4	115.0	91.8	92.3	326
C	4/20/96	4.26	<1.0	<1.0	43.1	59.5	92.8	2.7	105.0	235.0	161.0	699
D	2/24/93	6.44	4.3	342.0	261.0	730.0	1645.0	494.0	110.0	306.0	153.0	4050
D	8/28/94	6.31	<1.0	6.8	46.4	175.0	282.0	243.0	271.0	548.0	395.0	1970
D	5/26/95	6.56	<1.0	<1.0	3.0	5.1	9.1	<1.0	81.8	41.7	26.6	167
D	4/20/96	5.82	1.2	24.7	135.0	308.0	810.0	146.0	173.0	419.0	175.0	2192
E	2/24/93	6.52	2.1	4.1	38.2	199.0	566.0	66.1	85.4	217.0	72.0	1250
E	8/28/94	6.33	<1.0	3.6	35.2	163.0	596.0	62.5	123.0	338.0	84.3	1410
E	5/27/95	6.68	1.5	<1.0	19.0	105.0	300.0	25.1	42.0	300.0	36.5	829
E	4/20/96	5.87	1.5	2.9	25.7	113.0	341.0	58.0	60.0	278.0	44.7	925
EA6	2/24/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EA6	8/28/94	6.30	<1.0	1.1	30.5	133.0	459.0	3.2	131.0	203.0	86.5	1050
EA6	5/27/95	6.70	<1.0	<1.0	2.8	12.1	32.6	1.1	79.3	129.0	43.7	301
EA6	4/20/96	5.92	<1.0	<1.0	<1.0	1.8	4.1	<1.0	87.8	89.3	51.7	235

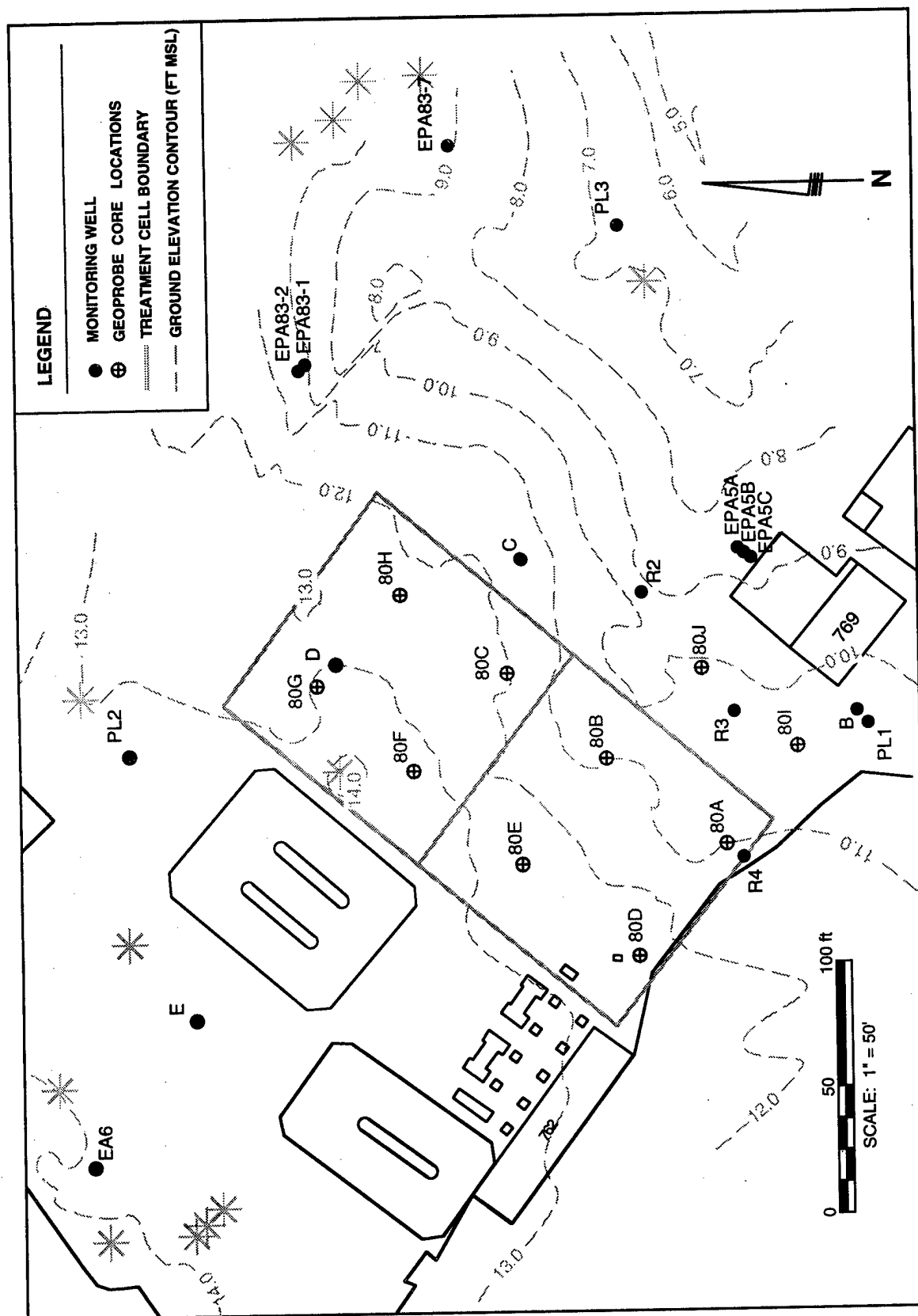


Figure 4. Geoprobe Sample Locations for Mar 93 Site Characterization, Prior to Pilot Project Operation.

Again, dissolved oxygen was low, especially from 7-11 feet below ground surface. Ammonia-nitrogen concentrations tended to increase with depth at most locations. One explanation for this may be that nitrification of applied fertilizer produced nitrate in the rhizosphere, which was then reduced to ammonia through dissimilatory nitrate reduction as the nitrate infiltrated through the contaminated region. This could happen with an aerobic soil zone and an anaerobic subsurface, providing there was sufficient available carbon. This would appear to be the case in the treatment area, since both TOC and BTEXTMB levels were high throughout the aquifer. In addition, sulfate levels were low and methane levels were high, with higher methane concentrations generally within the deeper regions of the aquifer. This would indicate that the aquifer microorganisms are metabolically active in this anaerobic environment. Benzene concentrations ranged from 0-300 µg/L and were erratically distributed with respect to total BTEXTMB (Table 3). This could indicate selective volatilization, leaching, or biodegradation, depending on the depth of the water sample and proximity to the original spill area. However, it also could indicate the presence of other spills. For example, the ratio of benzene to total BTEXTMB was 3% nearest the spill location (80E2), 13% downgradient of the spill (80I2), and 0.4% in the far corner of the proposed control cell (80H3). However, the corresponding BTEXTMB levels were 2550, 2280, and 24,100 µg/L in those locations. This does not correlate with preferential leaching of benzene from the original fuel spill. Without data from these locations prior to the fuel spill, it is difficult to determine whether all of the contamination at the site originated from the JP-4 jet fuel pipeline leak. Nonetheless, these data show that, despite the aerobic bioremediation provided by the hydrogen peroxide demonstration project, extensive contamination of the ground water occurs over the project area to a depth of at least 11 feet below ground surface.

3. Core Analyses

Core samples were taken on several separate occasions for various purposes. For example, previous site characterizations did not provide an adequate description of the near-surface aquifer, which contained most of the contaminants. Therefore, core samples which had been obtained during installation of the EPA1 and EPA2 wells were further characterized by direct microscopy and particle-size analysis (Jerome Cruz, ManTech Environmental Services, Inc). This section also describes the sampling, analytical methods, and results for the measurement of BTEXTMB and JP-4 in aquifer cores. This was done to delineate the lateral spread and vertical extent of contamination at the site and provide mass estimates. This information was also used to help define the locations of the proposed treatment cells.

a. Methods

Core samples were obtained using a Giddings probe modified for acquisition and extrusion of saturated aquifer material. Samples were collected using 2-inch hollow core barrels either with or without pistons to prevent loss of flowing

TABLE 3. GEOPROBE WATER QUALITY DATA FOR EGLIN AFB SITE PRIOR TO PILOT STUDY, 3/93

Area	Sample	Grade Elev. (ft MSL)	Bot. Screen (ft from GS)	Top Screen (ft from GS)	Bot. Screen (ft MSL)	Top Screen (ft MSL)	pH (pH units)	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)
Proposed Nitrate Treatment Cell	80A-1	11.08	5.00	3.50	6.08	7.58	6.01	1.1	4.80	<0.5	<0.5	0.08	<0.05	1.32	<0.05
	80A-2	11.08	8.00	6.50	3.08	4.58	6.13	0.3	5.30	<0.5	<0.5	0.09	<0.05	2.74	1.06
	80A-3	11.08	11.00	9.50	0.08	1.58	6.19	0.5	13.50	<0.5	<0.5	0.09	<0.05	3.35	1.43
	80B-1	10.92	4.00	2.50	6.92	8.42	5.60	0.5	7.00	<0.5	<0.5	0.08	<0.05	2.42	0.57
	80B-2	10.92	7.00	5.50	3.92	5.42	6.08	0.3	4.70	<0.5	<0.5	0.09	<0.05	4.74	0.89
	80B-3	10.92	10.00	8.50	0.92	2.42	6.07	0.3	4.30	<0.5	<0.5	0.09	<0.05	3.45	0.29
	80D-1	12.30	5.50	4.00	6.80	8.30	5.80	1.5	2.60	<0.5	<0.5	0.08	<0.05	0.55	<0.05
	80D-2	12.30	8.50	7.00	3.80	5.30	6.20	0.8	0.46	0.9	1.8	0.08	<0.05	0.76	0.23
	80D-3	12.30	11.50	10.00	0.80	2.30	6.20	0.8	1.80	1.4	1.2	0.08	<0.05	1.69	<0.05
Proposed Control Treatment Cell	80 E-1	12.28	5.50	4.00	6.78	8.28	5.70	1.1	2.70	2.8	1.7	<0.05	<0.05	1.48	0.14
	80 E-2	12.28	8.50	7.00	3.78	5.28	6.60	1.0	6.15	1.9	1.6	0.10	<0.05	2.46	<0.05
	80 E-3	12.28	11.50	10.00	0.78	2.28	6.70	0.9	1.13	0.5	0.9	0.09	<0.05	0.86	<0.05
	80C-1	11.98	5.70	4.20	6.28	7.78	6.20	0.5	2.00	<0.5	<0.5	0.18	<0.05	0.84	<0.05
	80C-2	11.98	8.70	7.20	3.28	4.78	6.40	0.4	2.30	<0.5	<0.5	0.10	<0.05	1.35	0.14
	80C-3	11.98	11.70	10.20	0.28	1.78	6.40	0.3	2.30	<0.5	<0.5	0.10	<0.05	1.13	0.36
	80F-1	13.44	5.50	4.00	7.94	9.44	6.10	1.3	0.50	<0.5	2.1	0.17	<0.05	1.85	<0.05
	80F-2	13.44	8.50	7.00	4.94	6.44	6.51	0.8	0.38	1.4	1.3	0.45	<0.05	1.74	0.06
	80F-3	13.44	11.50	10.00	1.94	3.44	6.65	1.3	0.09	<0.5	1.5	0.68	<0.05	0.05	0.07
Downgradient of Proposed Nitrate Treatment Cell	80G-1	13.01	5.70	4.20	7.31	8.81	5.98	0.9	1.18	0.6	1.3	0.09	<0.05	0.62	<0.05
	80G-2	13.01	8.70	7.20	4.31	5.81	5.63	0.4	0.37	1.0	2.2	0.09	<0.05	0.34	<0.05
	80G-3	13.01	11.70	10.20	1.31	2.81	6.48	0.6	0.97	0.5	1.9	0.09	<0.05	0.40	<0.05
	80H-1	12.50	5.70	4.20	6.80	8.30	5.12	1.2	2.40	0.8	1.3	0.08	<0.05	0.15	<0.05
	80H-2	12.50	8.70	7.20	3.80	5.30	5.95	0.4	7.50	1.5	9.6	0.09	<0.05	2.69	0.20
	80H-3	12.50	11.70	10.20	0.80	2.30	6.22	0.4	2.30	1.8	4.3	0.09	<0.05	1.23	<0.05
	80I-1	10.51	5.70	4.20	4.81	6.31	6.10	0.2	4.80	1.4	2.2	0.08	<0.05	0.85	0.07
	80I-2	10.51	8.70	7.20	1.81	3.31	5.90	0.3	5.80	2.7	1.8	0.09	<0.05	2.34	0.27
	80J-1	10.12	5.20	3.70	4.92	6.42	6.10	0.1	7.00	1.3	1.5	0.07	<0.05	5.14	1.42
Downgradient of Proposed Nitrate Treatment Cell	80J-2	10.12	8.20	6.70	1.92	3.42	6.20	0.1	8.30	2.0	1.3	0.08	<0.05	5.28	1.59
	80J-3	10.12	11.20	9.70	-1.08	0.42	6.20	<0.1	11.30	2.0	2.3	0.08	<0.05	4.55	0.43

TABLE 3 (cont). GEOPROBE WATER QUALITY DATA FOR EGLIN AFB SITE PRIOR TO PILOT STUDY, 3/93

Area	Sample	SO ₄ (mg/L)	TOC (mg/L)	CH ₄ (mg/L)	N ₂ O (mg/L)	BZ (µg/L)	TOL (µg/L)	ETBZ (µg/L)	PXYL (µg/L)	MXYL (µg/L)	OXYL (µg/L)	MESIT (µg/L)	PSCU (µg/L)	TMB (µg/L)	BTEXTMB (µg/L)
Proposed Nitrate Treatment Cell	80A-1	<0.5	30.5	3.01	<0.001	19.1	63.1	7.1	19.1	35.1	17.0	204.0	278.0	157.0	800
	80A-2	<0.5	32.2	8.65	<0.001	24.8	15.2	176.0	384.0	761.0	19.8	137.0	289.0	151.0	1960
	80A-3	<0.5	29.2	9.72	<0.001	16.8	10.1	115.0	202.0	405.0	12.8	49.2	144.0	53.5	1010
	80B-1	<0.5	40.4	3.73	<0.001	1.1	205.0	60.5	113.0	232.0	123.0	91.5	221.0	81.6	1130
	80B-2	<0.5	25.1	9.77	<0.001	4.2	39.3	198.0	254.0	324.0	41.8	89.2	284.0	59.6	1290
	80B-3	<0.5	24.5	9.00	<0.001	8.7	34.2	95.0	145.0	140.0	35.6	33.5	184.0	29.9	706
	80D-1	<0.5	10.0	0.12	<0.001	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	9.7	58.5	32.1	101
	80D-2	<0.5	13.2	3.15	<0.001	3.3	20.4	95.3	190.0	392.0	133.0	67.8	201.0	104.0	1210
	80D-3	<0.5	22.2	10.20	<0.001	17.0	105.0	615.0	906.0	1930.0	516.0	148.0	530.0	255.0	5020
Proposed Control Treatment Cell	80 E-1	<0.5	57.1	2.86	0.002	<1.0	165.0	492.0	773.0	1830.0	1210.0	163.0	347.0	217.0	5200
	80 E-2	<0.5	40.9	13.70	<0.001	76.2	12.6	544.0	450.0	812.0	81.3	71.0	416.0	76.3	2550
	80 E-3	<0.5	12.0	2.80	<0.001	1.0	2.4	18.8	26.6	53.0	20.9	9.1	21.8	10.2	164
	80C-1	<0.5	26.9	0.95	0.065	<1.0	11.6	8.2	36.6	64.8	51.8	207.0	480.0	308.0	1170
	80C-2	<0.5	12.6	9.58	<0.001	16.9	9.9	63.4	178.0	328.0	14.0	187.0	549.0	286.0	1630
	80C-3	<0.5	12.1	7.16	0.001	2.6	9.2	29.2	110.0	138.0	12.4	203.0	534.0	262.0	1300
	80F-1	5.0	20.0	4.61	0.001	<1.0	7.4	16.3	29.0	49.3	207.0	48.9	16.7	103.0	478
	80F-2	1.8	11.4	5.18	0.010	<1.0	209.0	640.0	933.0	2110.0	1610.0	226.0	601.0	254.0	6580
	80F-3	4.6	4.2	0.01	0.003	<1.0	2.9	13.1	22.8	48.8	35.8	8.4	17.1	10.4	159
Downgradient of Proposed Nitrate Treatment Cell	80G-1	0.5	8.9	1.00	0.006	<1.0	24.1	26.4	251.0	405.0	700.0	154.0	180.0	261.0	2000
	80G-2	1.3	6.0	2.70	<0.001	<1.0	970.0	590.0	1190.0	2550.0	1730.0	336.0	934.0	353.0	8650
	80G-3	<0.5	11.5	3.65	<0.001	<1.0	14.3	26.7	210.0	581.0	47.1	109.0	223.0	118.0	1330
	80H-1	1.6	6.3	1.01	<0.001	<1.0	2.7	4.4	13.7	26.5	14.2	33.4	66.0	40.4	201
	80H-2	<0.5	22.1	10.10	<0.001	29.4	941.0	350.0	691.0	1520.0	153.0	233.0	694.0	287.0	4900
	80H-3	1.6	18.1	3.70	<0.001	100.0	5150.0	1700.0	3120.0	6750.0	5480.0	327.0	1090.0	406.0	24100
	80I-1	<0.5	26.8	14.60	<0.001	54.8	61.9	129.0	340.0	678.0	133.0	15.0	45.7	30.2	1490
	80I-2	<0.5	29.5	12.20	<0.001	303.0	4.7	271.0	512.0	515.0	3.6	73.5	483.0	116.0	2280
	80J-1	<0.5	41.6	14.30	<0.001	5.8	1.6	202.0	192.0	182.0	<1.0	33.3	357.0	69.0	1040
Downgradient of Proposed Nitrate Treatment Cell	80J-2	<0.5	43.2	15.10	<0.001	9.0	1.7	229.0	213.0	63.2	<1.0	38.0	393.0	38.8	986
	80J-3	<0.5	53.1	13.00	<0.001	82.2	6.8	296.0	157.0	41.9	4.0	13.3	373.0	19.9	994

sands (Leach et al, 1989). Cores were extruded into sterile, clean half-pint Mason jars using a paring device to shave off the core material which had been in contact with the core barrel. The jars were immediately sealed and set aside until the entire core barrel had been emptied. Each core was then subsampled using a sterile, clean 10-mL tuberculin syringes with the tip removed. The core was subsampled to the bottom of the jar to provide a subsample representative of the entire core length. The subsample was immediately added to a tared 40-mL VOA vial containing 5 mL deionized water and 5 mL methylene chloride, and the vial was sealed with a Teflon®-lined silica septum and mixed. Extract vials were either stored on ice or at room temperature prior to transport to RSKERL for analysis.

Sample vials were weighed to determine mass of core sample added, and samples were then extracted by placing on a wrist-action shaker for 30 minutes and sonicating for 1 minute. The organic extract was removed with a syringe, passed through a sodium sulfate column, and fire-sealed in a glass ampule. For JP-4 analyses, samples were analyzed using a Hewlett-Packard 5880 GC with a flame ionization detector. Samples were chromatographed on a 30-m x 0.53-mm DB-5 capillary column with 1.5- μ m film thickness. The column was temperature programmed from 10°C (3.0 minutes) to 56°C at 4°C/minute, then to 75°C at 30°C/minute, then to 95°C at 2°C/minute, held for 1 minute, and then to 254°C at 30°C/minute with a final 8.0-minute hold. The column flow rate was 4.7 mL/minute. JP-4 concentrations were quantified with a 7-point external standard calibration curve ranging from 50-50000 mg/L. The detection limit is based on the initial mass of core sample; with core samples averaging around 30 grams, the detection limit was approximately 10 mg/kg on a wet weight basis.

BTEXTMB was quantified using a Hewlett-Packard 5890 GC equipped with a Hewlett-Packard 5971 mass selective detector. Cool (38°C) on-column injection was used with electronic pressure control set for a constant flow of 0.9 ml/minute. A 30-m x 0.25-mm Restek Stabilwax® capillary column with 0.5- μ m was used, preceded by a 230-mm x 0.53-mm uncoated capillary precolumn. The column was temperature programmed from 32°C (3.0 minutes) to 70°C at 4°C/minute, then to 200°C at 20°C/minute with a final 1.0-minute hold. Quantitation was based on calibration curves of a single target ion for each compound with the addition of up to two qualifier ions recorded to verify chromatographic separation or purity. The ions chosen were those listed in EPA Method 524.2 (Revision 3.0). Both low-level (0.01-10 mg/L) and high-level (10-300 mg/L) calibration curves were used, with fluorobenzene as the internal standard. The system detection limit was 0.02 mg/L, which provided for a method detection limit of approximately 0.003 mg/kg on a wet weight basis.

Selected core extracts were also subjected to an extensive GC/MS search to better define the distribution of the residual volatile hydrocarbons. Samples were chromatographed using a 30-m x 0.25-mm Restek Stabilwax capillary column with 0.5- μ m film thickness coupled to a 100-m x 0.25-mm DB-1 Petrocol column with a

0.5- μ m film thickness. Data were obtained in a scan mode ($m/z = 34$ to 450) and peak spectra were compared with library spectra to provide tentative identifications. These identifications were then sorted into separate compound classes using a computer program. A final manual spectral interpretation was made for all compounds which were not identified or where significant coelution was observed. A "calibration curve" was created from the analysis of 117 different petroleum compounds, including alkanes, alkenes, cycloalkanes, monoaromatic hydrocarbons, and polycyclic aromatic hydrocarbons. This curve was used to relate response factor to retention time ($r^2 = 0.977$), and provided a semiquantitative analysis of the weight percent of the various compound classes. For comparative purposes, concentrations of individual monoaromatic hydrocarbons (BTEXTMB) were also done this way.

b. Results

The core samples from Locations EPA1 and EPA2 appeared to be texturally mature to submature quartz sands commonly associated with a beach environment. The particle size analyses are shown in Table 4. The samples were basically unconsolidated, well-sorted medium-sized quartz sands, averaging 0.25 to 0.50 mm in diameter (Table 4). The particles were subangular to rounded, and ranged from subprismoidal to spherical in shape. There were occasional amber-colored quartz grains which were possibly coated with iron oxides. Detrital mafic grains occurred in minor amounts. Mafics may have been chloritic aggregates or pyroxenes, based on appearance after crushing. Plant material was common in the upper horizon samples, down to 3.5 to 4.5 feet below ground surface. Sand grains were coated with what appeared to be finer argillaceous soil material and quartz dust, down to about 4.5 feet for both core locations.

Core samples were also taken to delineate the distribution of BTEXTMB and JP-4. Initially, 22 locations were designated for the acquisition of continuous cores, including two which extended from ground surface to 20 feet below grade. The locations of these cores are shown in Figure 5. Core locations 80A-80J also correspond to the locations used for taking geoprobe samples, thus providing a direct comparison between core samples and water quality analyses. Data for these cores, as well as those taken later to assess the effects of pilot operation, are shown in Appendix A.

For each core location, concentrations of BTEXTMB and JP-4 in the individual subsamples were weighted for the sampled interval and summed to provide a total cumulative mass estimate in g/m^2 for that location. A bulk density of 1830 kg/m^3 was assumed for this calculation. Cumulative mass data for all of the core samples during the entire pilot project are shown in Table 5. Based on the analyses of the cores taken Mar 93 - Mar 94, a contour plot showing the cumulative mass distribution of TPH (as JP-4) across the site was constructed (Figure 5). The source is located in the proximity of 80U, and the resultant residual saturation is found distributed fairly evenly

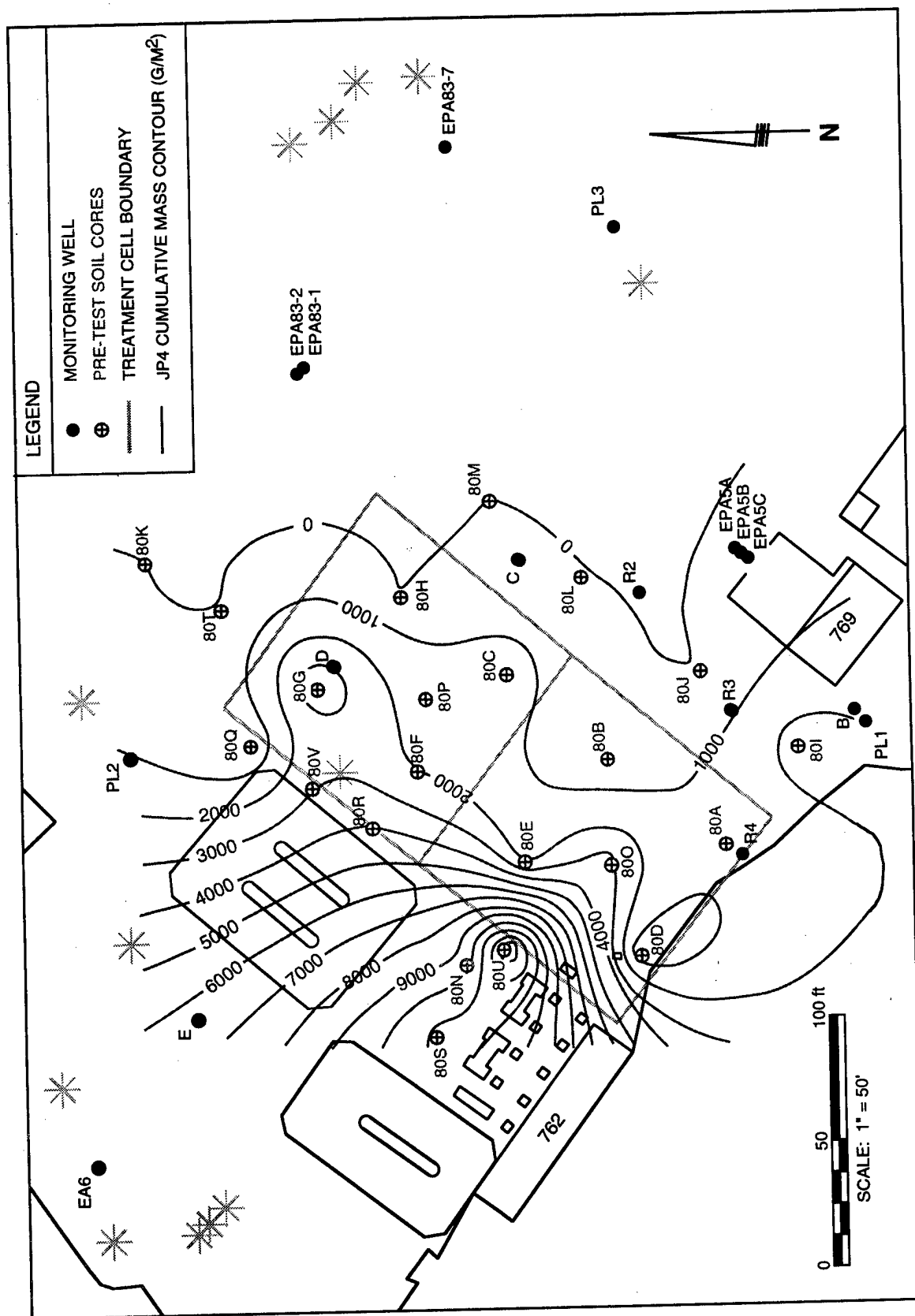


Figure 5. Location of Pre-Test Core Samples, and JP-4 Cumulative Mass Distribution Resulting from Core Analyses. Also Shown are the Treatment Cell Boundaries for the Pilot Demonstration Project.

TABLE 4. PARTICLE-SIZE ANALYSIS OF CORE SAMPLES FROM SELECTED DEPTHS AT WELL LOCATIONS EPA1 AND EPA2, EGLIN AFB

Well Location	Depth (ft from GS)	Weight Percent				
		<0.25 mm	0.25-0.50 mm	0.5-1.0 mm	1.0-2.0 mm	>2.0 mm
EPA1	1.0-1.5	16.60	46.50	34.50	2.33	0.10
	2.0-2.5	NA	NA	NA	NA	NA
	3.0-3.5	12.50	41.50	26.40	3.01	16.60
	4.0-4.5	15.40	48.60	32.10	3.89	0.00
	5.0-7.0	21.70	49.30	26.50	2.40	0.18
	7.0-9.0	16.40	53.10	28.20	2.27	0.00
	9.0-11.0	18.00	53.00	26.60	2.36	0.00
EPA2	1.0-1.5	26.00	51.90	20.30	1.66	0.16
	2.0-2.5	25.60	52.30	20.50	1.48	0.14
	3.0-3.5	26.80	50.30	21.30	1.49	0.00
	4.0-4.5	22.80	51.60	23.10	2.16	0.36
	5.0-7.0	13.10	52.80	30.30	3.84	0.00
	7.0-9.0	11.40	52.90	31.80	3.79	0.14
	9.0-11.0	9.41	54.50	32.10	3.96	0.00

across an area downgradient. The contaminated interval is 4-5 feet thick next to the source, but is generally 2-3 feet thick downgradient. The bottom of the contaminated zone (<10 mg/kg JP-4) ranges from 4-7 feet below land surface. Based on a 300-foot x 300-foot area which encompasses all 22 core locations, the total JP-4 mass was estimated to be 26800 kg (T. Fisher, personal communication). This is equivalent to 9300 gallons, assuming a density of 0.76 (Smith et al, 1981). In the 100-foot x 200-foot proposed treatment area, the JP-4 mass was estimated to be 2860 kg, based on simple averaging of cumulative masses for the core locations strictly within the treatment boundaries. At the time of the initial sampling (March), most of the JP-4 was located below the water table in the majority of the locations for which water table information was available.

TABLE 5. CUMULATIVE MASS DATA FOR ALL CORE SAMPLES COLLECTED DURING PILOT PROJECT

Sample ID	Date	Interval (ft)	BZ (g/m ²)	TOL (g/m ²)	ETBZ (g/m ²)	PXYL (g/m ²)	MXYL (g/m ²)	OXYL (g/m ²)	MESIT (g/m ²)	PSCU (g/m ²)	TMB (g/m ²)	BTEX (g/m ²)	BTEXTMB (g/m ²)	JP-4 (g/m ²)
80A	Mar-93	10.3	0.035	0.006	0.972	2.925	6.532	0.006	3.276	7.775	2.621	10.50	24.20	1170
80B	Mar-93	12.0	0.015	0.028	0.034	0.049	0.072	0.008	0.119	0.446	0.083	0.21	0.85	277
80C	Mar-93	7.0	0.001	0.010	0.032	0.130	0.208	0.132	2.972	3.638	2.226	0.51	9.35	1530
80D	Mar-93	10.0	0.014	0.085	0.224	0.336	0.843	0.420	0.077	0.704	0.163	1.92	2.86	387
80E	Mar-93	10.1	0.085	0.030	1.812	2.589	6.569	1.536	2.638	4.025	1.145	12.60	20.40	1640
80F	Mar-93	6.6	0.002	0.222	2.250	4.203	9.287	8.054	4.792	7.908	3.852	24.00	40.60	1800
80G	Mar-93	7.0	0.001	0.387	0.846	6.448	9.903	16.194	11.100	11.871	6.855	33.80	63.60	3760
80H	Mar-93	6.5	0.026	1.084	0.224	0.332	0.810	0.302	0.127	0.367	0.126	2.78	3.40	<10
80I	Mar-93	3.5	0.060	0.717	0.626	1.712	3.458	4.995	0.138	0.963	0.207	11.60	12.90	2380
80J	Mar-93	4.0	0.008	0.006	0.164	0.095	0.089	0.001	0.063	0.527	0.068	0.36	1.02	<10
80K	Mar-93	7.5	<0.001	<0.001	0.005	0.051	0.140	0.031	0.015	0.038	0.023	0.23	0.30	<10
80KC	Aug-94	7.3	<0.001	0.009	0.017	0.102	0.273	<0.001	0.022	0.053	0.021	0.40	0.50	<10
80KD	May-95	7.5	<0.001	<0.001	0.008	0.010	0.017	0.003	0.043	0.102	0.044	0.04	0.23	<10
80L	Mar-93	6.0	<0.001	0.101	0.099	0.231	0.510	0.424	0.166	0.352	0.150	1.37	2.03	18
80M	Mar-93	4.0	<0.001	0.005	0.026	0.051	0.120	<0.001	0.034	0.089	0.043	0.20	0.37	<10
80N	Mar-93	6.5	0.034	11.838	25.953	35.634	90.587	55.097	22.894	71.270	21.600	219.00	335.00	9190
80O	Jul-93	18.5	0.067	0.504	1.878	3.000	5.369	0.220	7.192	15.086	4.500	11.00	37.81	3240
80P	Jul-93	19.0	0.079	2.959	0.751	1.700	3.930	1.300	2.008	2.235	0.996	10.70	16.00	1440
80Q	Jul-93	10.0	<0.001	<0.001	0.031	0.136	0.370	0.024	0.026	0.065	0.036	0.56	0.69	<10
80R	Jul-93	7.5	0.004	0.039	0.251	2.096	2.963	5.292	11.629	10.274	11.200	10.70	43.70	3980
80S	Jul-93	8.0	0.019	2.500	32.751	46.500	95.463	51.465	28.143	64.822	30.400	229.00	352.00	11300
80T	Jul-93	7.0	0.006	0.001	0.008	0.232	0.592	0.039	0.055	0.133	0.070	0.88	1.14	<10
80U	Apr-94	11.4	0.149	37.007	43.918	56.648	129.273	81.553	41.687	101.008	41.200	349.00	533.00	13900
80V	Aug-94	8.4	<0.001	6.257	4.527	11.459	23.138	18.886	14.928	20.651	12.800	64.30	113.00	3010
80W	Aug-94	7.5	<0.001	0.019	0.034	0.343	0.318	0.507	8.477	10.880	8.720	1.22	29.30	3590
80X	Aug-94	7.5	0.210	0.275	74.997	85.191	212.058	0.611	235.671	144.421	55.500	373.00	809.00	19000
80Y	Aug-94	8.4	<0.001	0.019	0.316	0.709	1.307	0.709	1.231	3.309	1.200	3.06	8.80	1820
80Z	Aug-94	7.4	0.008	0.036	3.978	6.597	12.188	0.186	10.293	19.756	8.140	23.00	61.20	4230
80ZA	Aug-94	7.5	<0.001	0.011	0.002	0.006	0.018	0.034	1.496	0.890	0.712	0.07	3.15	2710
80ZB	Aug-94	7.5	0.002	0.010	0.025	0.124	0.162	0.026	1.060	1.327	1.460	0.35	4.20	1040
80ZC	Aug-94	7.5	0.002	0.023	0.651	4.779	7.732	4.328	12.432	18.674	9.170	17.50	57.80	3720
80ZD	Aug-94	7.5	<0.001	0.012	0.007	0.024	0.019	0.014	1.130	0.445	0.268	0.08	1.92	1300
80ZE	Aug-94	7.5	<0.001	<0.001	0.005	0.032	0.042	0.041	0.130	0.155	0.113	0.12	0.52	<10
80ZF	Aug-94	7.5	<0.001	<0.001	<0.001	0.002	0.005	0.001	0.113	0.075	0.096	0.01	0.29	<10
80ZG	Aug-94	7.5	0.011	0.096	27.549	49.944	111.202	0.388	47.366	99.465	42.000	189.00	378.00	13400

TABLE 5 (cont). CUMULATIVE MASS DATA FOR ALL CORE SAMPLES COLLECTED DURING PILOT PROJECT

Sample ID	Date	Interval (ft)	BZ (g/m ²)	TOL (g/m ²)	ETBZ (g/m ²)	PXYL (g/m ²)	MXYL (g/m ²)	OXYL (g/m ²)	MESIT (g/m ²)	PSCU (g/m ²)	TMB (g/m ²)	BTEX (g/m ²)	BTEXTMB (g/m ²)	JP-4 (g/m ²)
80ZH	Aug-94	5.5	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.01	<10
80ZI	Aug-94	5.0	0.002	0.015	<0.001	0.030	0.014	0.017	5.564	0.134	2.270	0.08	8.04	1870
80ZJ	Aug-94	5.0	0.002	0.129	4.119	10.272	20.578	8.540	32.820	75.348	29.200	43.60	181.00	8340
80ZK	May-95	6.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.002	<0.001	<0.01	0.02	520
80ZL	May-95	6.5	<0.001	1.284	12.278	20.445	42.438	25.094	20.401	43.180	16.000	102.00	181.00	5660
80ZM	May-95	7.0	0.066	0.043	18.403	23.203	49.084	0.203	22.194	55.349	17.200	91.00	186.00	8390
80ZN	May-95	6.8	<0.001	0.006	0.331	1.083	0.412	0.770	6.670	15.323	6.130	2.60	30.70	3990
80ZO	May-95	6.5	0.001	0.054	0.863	2.100	4.024	2.175	13.560	31.947	11.900	9.22	66.70	4750
80ZP	May-95	6.5	<0.001	0.007	0.021	0.314	0.148	0.086	10.155	16.293	5.890	0.58	32.90	4600
80ZQ	May-95	6.5	<0.001	<0.001	0.001	0.012	<0.001	0.001	0.105	8.921	1.933	0.01	10.97	4630
80ZR	May-95	6.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.349	0.127	<0.01	0.48	2590
80ZS	May-95	7.4	<0.001	0.003	<0.001	0.014	0.011	0.005	0.037	0.855	0.405	0.03	1.33	2070
80ZT	May-95	6.6	<0.001	<0.001	0.003	0.025	0.033	0.016	1.892	0.679	1.055	0.08	3.70	4220
80ZU	May-95	6.6	<0.001	<0.001	0.065	0.228	0.392	0.423	11.929	3.850	3.053	1.11	19.90	4030
80ZV	May-95	6.5	<0.001	0.002	<0.001	0.003	0.004	<0.001	4.610	0.651	0.636	0.01	5.91	3090
80ZW	May-95	5.9	<0.001	0.002	0.009	0.033	0.023	0.015	3.540	0.340	0.498	0.08	4.46	4210
80ZX	May-95	6.2	<0.001	0.009	<0.001	<0.001	<0.001	<0.001	7.266	5.142	4.640	0.01	17.10	1500
80ZY	May-95	7.0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	2.996	0.765	0.355	<0.01	4.12	3950
80ZZ	May-95	7.0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.080	0.102	0.119	<0.01	0.30	<10
80ZZA	May-95	7.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.065	0.012	0.027	<0.01	0.10	<10

Subsamples were taken from each of the core locations, generally representing the most contaminated interval, and analyzed for distribution of compound classes relative to JP-4 fresh fuel samples (Table 6). In general, weathering had reduced the aromatic and cycloalkane fractions by 3% and 4%, respectively. Core locations 80D and 80I were unusual in that the alkane fractions were significantly higher than those in the other cores. For location 80I, the high benzene concentrations in the soil and water, coupled with the extent of surface soil contamination, suggested that this may have resulted from another source, perhaps spillage from the surface transfer station. The last four cores in Table 6 had very low "JP-4" levels, and therefore the distribution of compound classes may not be valid. However, core analyses revealed that there may be deeper plumes which probably originated from other upgradient locations. This is shown by high levels of benzene and toluene, but not alkanes, in the soil 9 feet below surface at location 80H (Appendix A), and is substantiated by the geoprobe water quality information from that location as well. For example, the weighted average core concentration of toluene in cores 80H8-80H11, covering the depth interval 7.2-8.7 feet below ground surface, was 0.208 mg/kg (Appendix A). Assuming a bulk density of 1830 kg/m³ and a porosity of 30%, the expected aqueous concentration of toluene, excluding sorption, would be 1270 µg/L. The geoprobe location 80H-2, screened from 7.2-8.7 feet below ground surface, yielded water with a toluene concentration of 940 µg/L, which is within 30% of the calculated value.

Analysis of the JP-4 jet fuel reveals that BTEXTMB makes up about 45% of the total aromatics, and the total aromatics make up about 17% of the JP-4. In contrast, based on analysis of BTEXTMB concentrations in the core samples listed in Table 6, BTEXTMB makes up about 2-36% of the total aromatics in the weathered cores, with the higher percentages closer to the spill area. The total aromatics make up about 14% of the residual JP-4. In fresh JP-4 jet fuel, the weight percentages of the target compounds were 1.18% for benzene, 2.43% for toluene, 0.47% for ethylbenzene, 0.47% for *p*-xylene, 1.61% for *m*-xylene, 0.93% for *o*-xylene, 0.60% for mesitylene, 0.88% for pseudocumene, and 0.49% for 1,2,3-trimethylbenzene. In general, the mass ratios of benzene and toluene to combined BTEXTMB were lower than expected, and in several cases *o*-xylene mass ratios were also very low (Appendix A). The benzene and toluene losses may have been due in part to the earlier remediation study using hydrogen peroxide, but the selective loss of *o*-xylene relative to the other xylene isomers is puzzling. Other studies have shown that toluene and *o*-xylene are rapidly degraded in anaerobic zones where iron reduction and sulfate reduction predominate (Borden et al, 1995), and it is possible that these compounds were being degraded under natural conditions in certain locations. However, this was not uniform, and other locations at the site (eg, 80D, 80F, 80G, 80L) showed the expected ratio of *o*-xylene to the other target compounds. These weight percentages show that the JP-4 jet fuel is weathered, and can be used to estimate total nitrate demand. Assuming that the treatment area contains 2860 kg of JP-4, 14% of which are aromatics, this yields 400 kg of aromatics. A conservative estimate would be

TABLE 6. DISTRIBUTION OF COMPOUND CLASSES IN JP-4 JET FUEL
AND CONTAMINATED CORES, EGLIN AFB

Core	Alkanes (wt %)	Aromatics (wt %)	Cycloalkanes (wt %)	Alkenes (wt %)	PAHs (wt %)	Other (wt %)	JP-4 (mg/kg)
JP-4	57.79	15.89	18.87	1.90	4.61	0.93	-
JP-4	59.30	17.70	17.50	0.94	3.65	0.95	-
Mean	58.55	16.80	18.19	1.42	4.13	0.94	
Stdev	1.07	1.28	0.97	0.68	0.68	0.01	
80A12	63.06	14.14	14.24	1.05	4.41	3.03	1850
80B12	69.16	9.19	16.21	0.36	2.69	2.27	375
80C3	67.77	12.13	13.51	0.32	4.84	1.34	926
80 E15	60.99	13.27	20.59	0.36	3.85	0.98	3270
80F15	62.16	18.13	10.93	1.74	5.50	1.47	2570
80G3	66.50	13.18	11.41	3.19	4.08	1.59	4230
80N2	61.43	17.23	11.32	0.99	7.42	1.54	3370
80O13	60.16	12.34	15.31	1.62	8.96	1.61	10700
80P15	62.69	14.02	12.34	2.52	7.30	1.13	2350
80R9	60.42	13.27	14.58	1.50	8.36	1.87	7720
80S9	61.64	15.41	11.99	1.29	7.68	2.00	11700
80U2	66.50	12.80	15.12	0.00	2.02	3.49	15500
80V1	68.70	13.70	12.00	0.74	0.21	4.66	3340
Mean	63.94	13.75	13.81	1.21	5.18	2.08	
Stdev	3.29	2.26	2.67	0.92	2.66	1.06	
80D12	75.10	9.97	9.38	0.68	2.60	2.16	595
80I4	82.96	1.71	11.61	0.97	1.19	1.56	2010
80H7	0.00	100.00	0.00	0.00	0.00	0.00	12
80J6	93.80	0.00	6.25	0.00	0.00	0.00	<10
80L3	12.77	59.81	0.00	0.00	11.34	13.44	18
80M2	0.00	18.20	0.00	0.00	81.80	0.00	<10

that 20% of the aromatics can be degraded under denitrifying conditions, leading to a nitrate demand of 80 kg NO₃-N for both treatment cells, assuming complete denitrification (Hutchins et al, 1991b). Actually, other sinks for nitrate would (and ultimately did) lead to increased nitrate consumption beyond that afforded by the labile aromatic hydrocarbons alone.

4. Laboratory Column Testing

Previous operation of the hydrogen peroxide pilot demonstration project had caused a drastic reduction in the aquifer's hydraulic conductivity, which inhibited delivery of the nutrients and hydrogen peroxide to the subsurface and thus limited its efficacy. Hinchey et al (1989) attributed the clogging to iron and/or phosphate precipitation, despite laboratory data showing that the nutrient solution formed no precipitate when combined with the soil. Because the same problems could adversely affect the nitrate-based pilot demonstration project, the following laboratory column tests were undertaken to identify the cause of the reduced hydraulic conductivity and recommend a treatment plan. These tests were conducted by Mark Wiesner and Mae Grant at Rice University, and the results have been published elsewhere (Wiesner et al, 1996). The following is a summary of their results.

a. Media Characteristics

Uncontaminated background aquifer core material was collected 5.5-9.0 feet below ground surface at location 80K, using an anaerobic glovebox. Analysis of the uncontaminated soil yielded a silt content of 4.2% by weight, and the Rice University Automated Sediment Analyzer (RUASA) gave an average grain size of 350 µm. The silt contains clay particles as small as 0.65 µm, as measured by dynamic light scattering. Bulk density of the soil was 1.61 g/mL, determined from the dry mass of soil and its volume when saturated. The dry soil density was 2.62 g/mL, determined from the density of a suspension prepared by placing a known weight of oven dried soil in a 50-mL volumetric flask and filling the remaining volume with water. These experimentally-determined densities gave a porosity of 0.385 for the uncontaminated background aquifer material (Hillel, 1971).

Analyses were conducted to characterize raw ground water samples received from the site. The iron concentration in the raw water was measured using a HACH spectrophotometer after filtering through a 0.45-µm filter to remove the particulates; the total iron was 0.03 mg/L. No ferrous iron was detected in the filtered water. When the ground water was acidified with nitric acid to bring the pH down to 1.98, some of the iron in the soil was dissolved. After filtering the acidified sample through a 0.45-µm filter, measurements revealed a higher total iron concentration (1.01 mg/L) and a slight ferrous concentration (0.01 mg/L). Ground water from the remediation site appeared rather turbid, implying a high content of suspended clay particles about 0.5-2.0 µm in size. Column tests were conducted on raw water and

water that had been allowed to stand for 5 days to allow some of the larger particles to settle. Dynamic light scattering (DLS) experiments on the inlet water that had settled for 5 days detected particles as small as $0.3\ \mu\text{m}$ and gave an average size of $0.61\ \mu\text{m}$. Measurements from a Coulter Multisizer gave a particle number concentration of $3.32 \times 10^9/\text{L}$ and an average particle size of $0.77\ \mu\text{m}$, which was consistent with the DLS measurements. In contrast, the light scattering measurements on the raw water yielded an average size of $0.744\ \mu\text{m}$ while the Coulter Multisizer gave an average of $0.84\ \mu\text{m}$ with a number concentration of $8.6 \times 10^9/\text{L}$. Dynamic light scattering measurements found no particles in the effluents in both cases, strong evidence that all suspended particles in the inlet water were retained in the aquifer soil within the column. To simulate the nutrient solution "Restore® 375", a stock salt mixture was prepared containing ammonium and phosphate salts according to the referenced weight fractions of the major ions (Hinchee et al., 1989). Trisodium tripolyphosphate was replaced by monosodium phosphate. The final stock salt mixture contained 50% NH_4Cl , 20% Na_2HPO_4 , and 30% NaH_2PO_4 .

b. Experimental Apparatus and Procedures

A laboratory apparatus was designed to investigate the cause of reduced permeability in the sandy aquifer. The apparatus consists of two reservoirs, two magnetic stirrers, an Ismatec® pump, a flowmeter, a pressure sensor (range 0-60 psi), and a Spectrum® chromatography column with cross-sectional area of $4.91\ \text{cm}^2$ and adjustable height. The column was prepared by placing 15 to 20 mL of water in the column, transferring the saturated soil into the column using a spatula, and gently tapping on the column wall after each addition of sand. This ensured a dense air-free packing. A column was usually packed to about 4 cm for fast flow and 8 cm for low rates. Each experiment was repeated for reproducibility.

A few experiments were conducted at a flow rate of 1 mL/minute (minimum achievable with the pump) giving a linear velocity of $3.4 \times 10^{-3}\ \text{cm/sec}$, which is an order of magnitude higher than the estimated ground water flow rate of 1.7 to $3.3 \times 10^{-4}\ \text{cm/sec}$ (Hinchee et al, 1989). Since the objective was to identify the cause of changes in permeability at the injection wells, most experiments were performed at a flow rate corresponding to the 5-10 gpm specified at the injection wells. For a 6-inch by 8-foot injection well, a 5 gpm injection rate yielded a linear velocity of $2.7 \times 10^{-2}\ \text{cm/sec}$. Numerous column tests were conducted at 10 mL/minute, giving an equivalent velocity of $3.4 \times 10^{-2}\ \text{cm/sec}$, which is on the same order of magnitude as the injection velocity. In addition, the experiments were conducted for inlet waters of different composition in order to identify the effect of each component on the permeability of the aquifer soil in a packed column.

c. Results and Discussion

- (1) Raw Ground water. The ground water was placed on a stirring

plate to keep the particulates in suspension while being pumped through the packed column. Within a few minutes, K dropped to 0.2 darcies as a result of particle migration, but fell by another order of magnitude to 0.02 darcies within an hour. The experiment was stopped because the pressure drop exceeded the limit of the pressure sensor. Later, ground water was allowed to sit without stirring for one day before passing through a packed column. The raw water was then allowed to sit undisturbed for another 4 days before column testing. Repeated measurements were performed to ensure reproducibility for each one of the three different inlet conditions. The hydraulic conductivity was reduced in the same manner for all three cases, suggesting that clay particles smaller than $1\text{ }\mu\text{m}$, which do not settle easily, are solely responsible for the reduction in permeability. Migration or rearrangement of the clay particles in the soil accounts for the initial decrease in the permeability of the packed bed. As more clay particles are introduced into the column in the feed stream and deposited inside the porous packing material, the permeability declines and requires higher energy to achieve the same flow rate. This result has been observed in deep bed filtration (O'Melia and Ali, 1978).

(2) Filtered Ground water. Filtering the ground water through $0.45\text{-}\mu\text{m}$ filters improved hydraulic conductivity significantly. While the raw water continued to plug the porous medium, reducing K by an order of magnitude, the filtered water achieved a steady-state permeability of about 0.15 darcy. We also investigated the effect of precipitation of calcium and/or iron phosphate salts in ground water or soil. The stock salt mixture was then added to the filtered ground water at the delivery concentration of 1000 mg/L and pH of 6.69. After the initial decline due to rearrangement of fines, data showed no further reduction in permeability compared to that using filtered ground water. This strongly indicates that any interaction that might occur between the nutrient solution and the soil in the column does not affect the permeability of the sandy porous medium. Finally, FeCl_3 was added to the filtered ground water containing nutrient solution to make a Fe^{3+} concentration of 10 mg/L. White flocs of $\text{Fe}(\text{H}_2\text{PO}_4)_3$ formed in the reservoir, giving a pH of 6.48. Filtered ground water was pumped through the column for 1 hour before switching to the solution with added nutrient and Fe^{3+} ; no significant loss in hydraulic conductivity was detected. Measurements using the "loaded" solution showed the same permeability as the filtered ground water.

d. Conclusions

These laboratory column tests demonstrated that clay particles less than $1\text{ }\mu\text{m}$ in size, either in the soil or in the ground water, plugged up the pores much more rapidly than those of iron and iron phosphate precipitates. Therefore, use and recirculation of the shallow ground water would require an above-ground treatment unit capable of removing clay particles in the submicron range, such as a membrane filtration device or a conventional packed bed filter. Based on this analysis, it was

recommended that the water used for recharge should be obtained from a different source and should not be recirculated.

5. Infiltration Testing and Modeling

The previous hydrogen peroxide pilot demonstration project used several different methods for applying nutrients and peroxide to the subsurface, including spray application, infiltration galleries, and subsurface injection (Hinchee et al, 1989). Application of solution through sprinklers was chosen as the distribution method for the current project on nitrate-based bioremediation. This method offers a number of potential advantages over injection wells and infiltration galleries. Because surface application systems primarily employ sprinklers or soaker hoses, equipment costs and installation costs are low. No drilling or excavation is required as in the cases of injection wells and infiltration galleries, and operational problems in surface application systems can be easily detected and corrected because the entire system is above ground. In addition, oxygen can be incorporated at low concentrations into the recharge without additional pumps or compressors. One of the primary advantages of surface application is that, since fuel spills are relatively narrow in depth but can cover a wide area, the infiltrated water will have a shorter flowpath through the contaminated interval, thus maximizing mass transfer of electron acceptors or other components. However, design of a surface application system does require significant characterization of site hydrogeology as well as a quantitative understanding of site specific infiltration and water table mounding characteristics. In addition, even surface distribution of sprinkler recharge is required not only to build the water table mound, but to avoid "dead zones" of stagnant subsurface water which counteract overall efficiency of remediation.

The following studies were therefore conducted to evaluate the feasibility of surface application as a means of supplying nitrate for the pilot-scale demonstration project. Specifically, the objectives of these tests were to: (1) model the formation and dissipation of a water table mound and the vertical migration of a conservative tracer during a field-scale infiltration and tracer experiment at the site, and (2) design a hydraulic scheme for both the formation of a ground water mound and the delivery of nitrate for the pilot project. These studies were carried out by Howard Sweed and Phil Bedient of Rice University, and the results have been published elsewhere (Sweed et al, 1996). The following is a brief summary of their work.

a. Infiltration/Tracer Test Design

Field-scale experiments were conducted in July 1993 to determine the suitability of surface application for the pilot project. An infiltration test was designed to characterize the infiltration characteristics of the site and to provide site-specific information about the formation of ground water mounds in response to surface application. A vertical tracer test was also conducted simultaneously to characterize

the vertical transport characteristics of the system. The infiltration test and vertical tracer test were conducted at two test plots measuring 15 feet x 10 feet (Figure 6). Each test was established around five piezometers which were used for collection of samples for both water quality and water table elevation data. Each test plot also contained two multilevel discrete cluster wells. Each of the cluster wells was constructed of 1/4-inch polypropylene tubing with a 2.5-inch, 80-mesh screen and installed in separate boreholes 0.5 feet apart using a geoprobe. The four screens were located at 1-foot intervals ranging from 1 foot above to 2 feet below the ambient water table (Figure 7).

The objectives of the infiltration test were to qualitatively observe infiltration behavior and to quantify the formation and dissipation of the ground water mound formed in response to the infiltration. Because results from the March 1993 cone penetrometer investigation identified low permeability material at the ground surface in several locations, the initial experimental design employed a small application rate to limit ponding and runoff. However, later examination of the surface soils in the test plot locations indicated higher permeabilities. After applying the design flow rate of 4.5 inch/day through soaker hoses alone for 17 hours, the soil within the test plots remained dry and no mound had formed. Consequently, the application rate was increased to 46 inch/day through the use of sprinklers, until a satisfactory mound had formed. Subsequently, sprinklers were removed and application of 10 inch/day from the soaker hoses continued for the duration of the experiment. The effective average application rate over the duration of the experiment was 36 inch/day.

The conservative tracer test simulated vertical transport of nitrate under field conditions through the use of sodium bromide. Specifically, the tracer experiment was designed to provide information on the travel time from the surface to the contaminated zone, the retention time of the tracer within the contaminated interval, and the depth to which chemicals applied at the surface would reach. Surface application of the tracer began immediately after the sprinklers were removed. The design flow rate of bromide stock solution into the bulk flow was 1.2 mL/minute, but was increased to 20 mL/minute to maintain the desired application concentration of 80 mg/L Br when the water application rate was increased.

b. Infiltration Test Results and Modeling

Infiltration of unamended tap water resulted in the formation of ground water mounds beneath both test plots. The water table increased by a maximum of 1.1 feet at Test Plot 1 and 0.5 feet at Test Plot 2. As expected, the rate of mound formation and dissipation at the field scale was strongly related to the surface application rate. Test Plot 1 exhibits very uniform mounding behavior; Test Plot 2 results indicate slightly more variability, although the general trends at the two locations are similar. The difference in maximum mound heights indicates a difference in hydraulic conductivity between the test plots. Modeling of the hydraulics of mound formation and

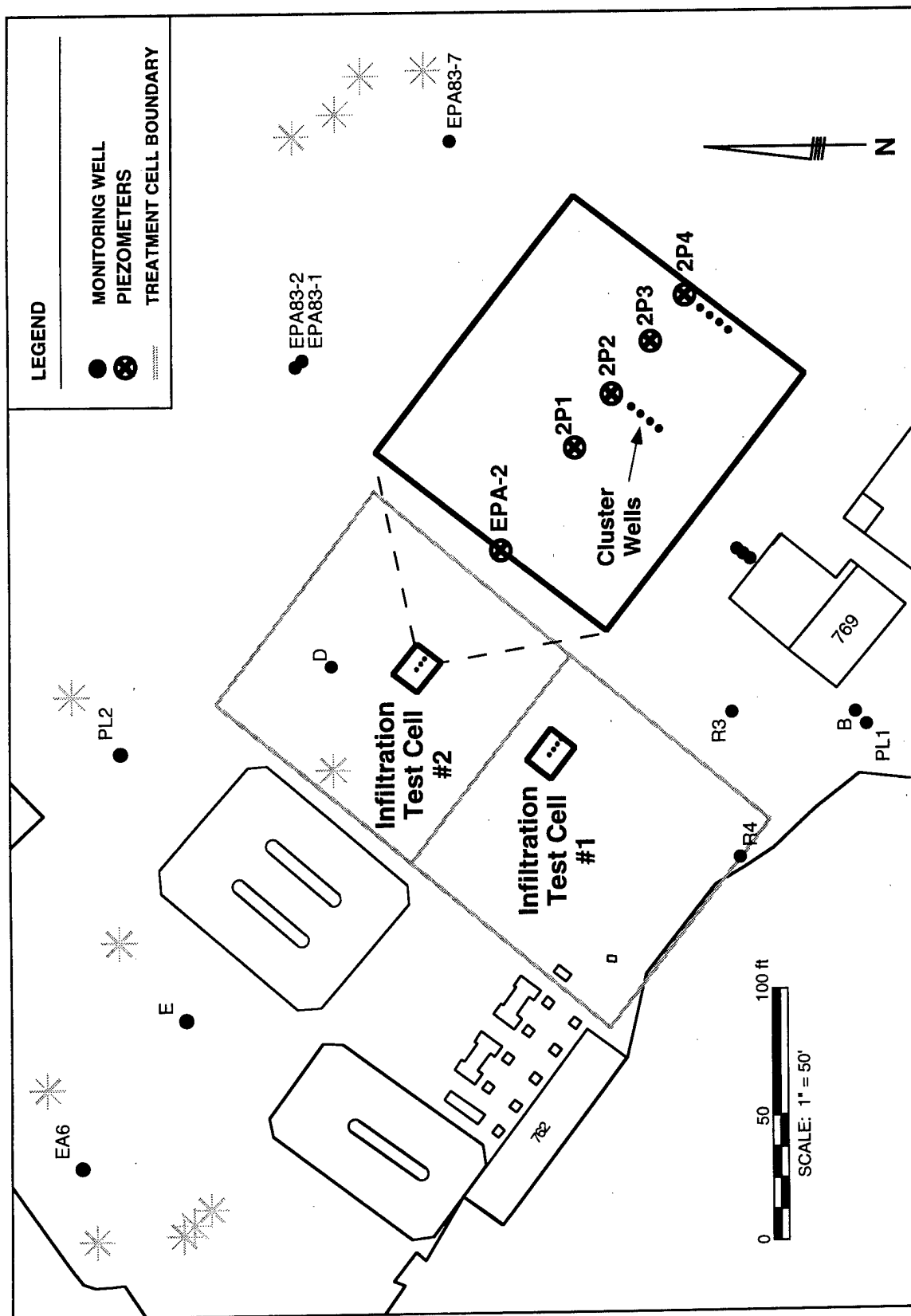


Figure 6. Location of Infiltration Test Cells for Hydraulic Characterization Prior to Remediation.

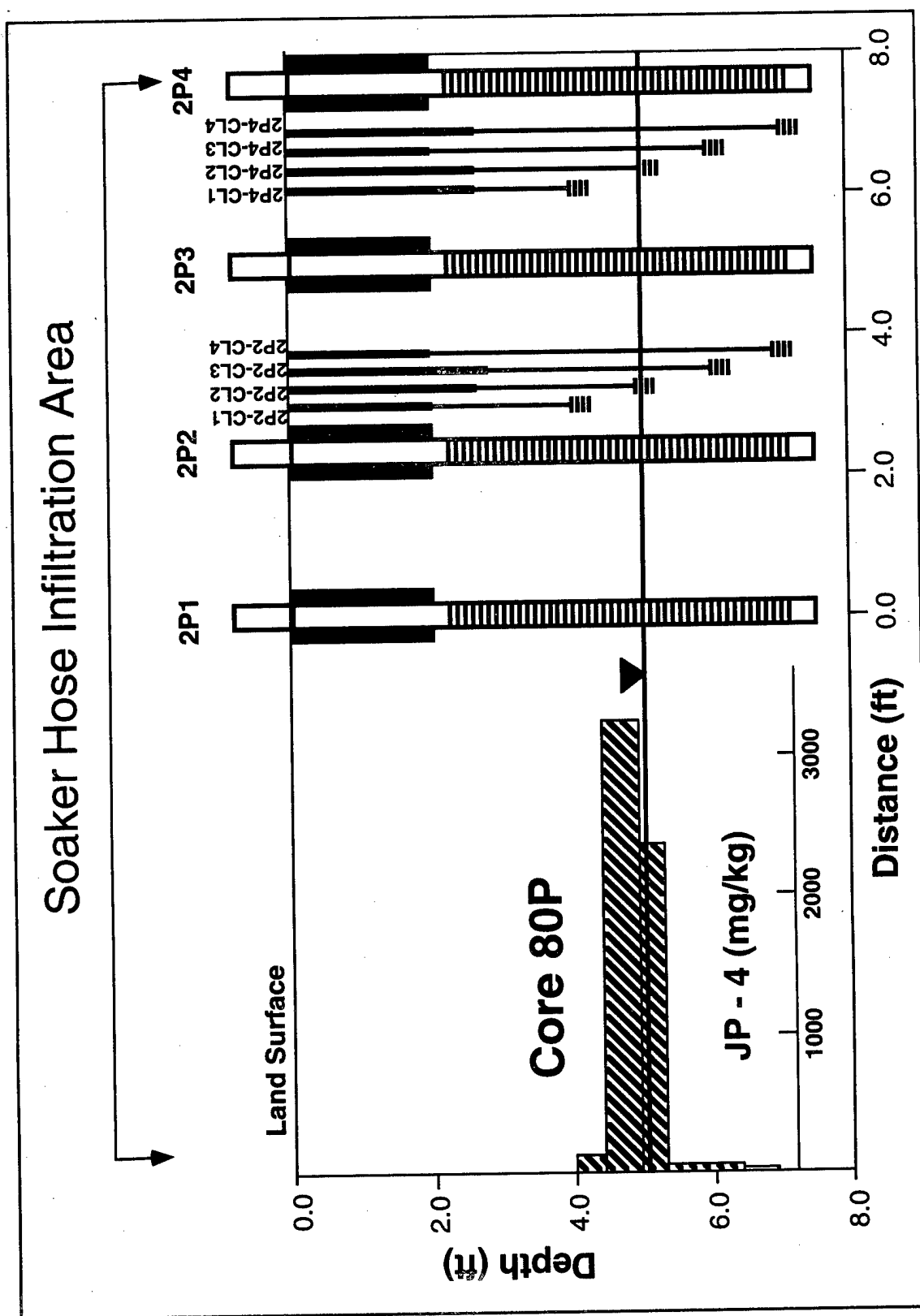


Figure 7. Cross-Section of Infiltration Test Cell #2, Showing Position of Piezometers and Cluster Wells Relative to Water Table and Contaminant Distribution.

dissipation with the two-dimensional ground water numerical model BIOPLUME II (Rifai et al, 1987) was conducted to achieve three objectives: (1) to calibrate the model to the results obtained during the infiltration test, (2) to estimate the hydrogeological parameters necessary for predictive modeling at the site, and (3) to predict ground water mounding response to various scenarios for the larger pilot-scale treatment cells to be used in the nitrate-based pilot test. Although BIOPLUME II simulates ground water flow in a confined aquifer, the applicability of the model to a water-table mounding scenario was validated through good agreement of the BIOPLUME II predictions with predictions based on the classic mounding analysis developed by Hantush (1967).

The model was calibrated to the mounding data from both Test Plot 1 and Test Plot 2. Hydraulic conductivities of 2×10^{-2} cm/sec and 4.5×10^{-2} cm/sec were used for Test Plots 1 and 2, respectively, and the respective hydraulic gradients were 0.013 and 0.001 feet/feet. The saturated thickness, storativity, and porosity were 5 feet, 0.20, and 0.385, respectively. The surface application was modeled in four time periods to simulate the different schemes implemented during the experiment. These schemes involved the use of both sprinklers and soaker hoses; sprinklers were modeled as injection wells while soaker hoses were simulated as diffuse recharge. The formation of the mound was observed as an increase in hydraulic head, since no vertical dimension exists in the 2-D BIOPLUME II model. Good agreement was obtained in the calibration between the observed and predicted mounding data; the maximum peak of 1.12 feet at Test Plot 1 predicted by the model agrees well with the maximum of 1.1 feet observed in the field in piezometer 1P1 (Sweed et al, 1996). Similarly, the predicted maximum mound of 0.49 feet corresponds to the maximum observed water table rise of 0.47 feet in piezometer 2P1.

Modeling of the observed response of the water table during the test plot infiltration test provided estimates of the site-specific hydrogeological parameters necessary for predictive modeling of the pilot-scale system. Predictive modeling runs were used to anticipate the extent of water-table mounding under a variety of surface application schemes. The simulation of surface application to the proposed pilot treatment cells required only 1 time period, because a constant application rate was assumed. Because subsurface heterogeneities were observed across the pilot test areas, a number of hydrogeologic schemes were modeled to determine the optimal hydraulic design. Based on the existing water table and the vertical distribution of contaminants, a mound of 2.5 feet was considered to be necessary for the pilot-scale system to inundate the contaminated intervals of the unsaturated zone and create a sufficient hydraulic gradient to force the nitrate into the subsurface. The modeling indicated that, because the pilot test will cover a much larger area (100 feet x 200 feet) than the infiltration test plots, this water table rise will occur at significantly lower application rates than those used during the infiltration experiment. Based on the predictive runs (data not shown), a surface application rate of 2.88 inch/day (25 gpm across the two pilot treatment cells) was chosen as the design flow rate to achieve the

desired mound.

c. Tracer Test

The ground water mounds formed at the test plots provided favorable hydraulic conditions for vertical transport of the sodium bromide tracer. The following analysis focused on the cluster wells at the outside edges of the test plots. At Cluster Well 1P4, the front reached CL1 very shortly after tracer application began and proceeded through the other multilevel ports, in order, reaching the deepest monitoring point, CL4, after approximately 20 hours (Sweed et al, 1996). Decreasing concentrations of bromide were detected in reverse order following the cessation of tracer application. A similar downward migration pattern was observed at Cluster Well 2P4. The observed lag between the breakthrough at CL2 and CL3 and between the breakthrough at CL3 and CL4 is related to the hydraulic retention time (HRT) of the system. This retention time represents an experimental determination of the residence time of bromide within the contaminated zone and an estimate of the time available for denitrifying organisms to consume nitrate during the bioremediation experiment. For the 3-foot contaminated interval, the HRT was estimated to be 9 hours at Test Plot 1 and 27 hours at Test Plot 2. This discrepancy is most likely caused by subsurface heterogeneities. The smaller water table mound at Test Plot 2, caused by the higher hydraulic conductivity, creates a smaller vertical driving force, and thus the travel time out of the zone is greater.

d. Conclusions

This study has demonstrated the site characterization and computer modeling necessary for the development and design of the surface application system. The test plot-scale infiltration test provided qualitative and quantitative information about site-specific infiltration and water table mounding characteristics. At the test site, 36 inch/day was applied via surface application to the two test cells; water table mounds of 1.1 feet and 0.5 feet were observed. A vertical tracer test demonstrated that hydraulic conditions were favorable for transport of chemicals from the surface to the contaminated interval of the subsurface under these conditions. These data suggested that similar operation of the pilot project at 25 gpm across the two pilot treatment cells would create the vertical gradient necessary to drive the electron acceptor to the contaminated zone.

6. Microbial Characterization

Measurements of microbial activity are essential in assessing the feasibility of bioremediation. Biofeasibility usually is assessed by determining the biodegradation potential of contaminants in laboratory treatability studies, which is often coupled with estimating microbial numbers. Laboratory tests are conducted to determine the potential for contaminant biodegradation and nutrient amendments that

will enhance biodegradation rates. Microbial counts can be used as a preliminary indicator of microbial activity before conducting more expensive treatability tests. However, assessing biofeasibility using determinations of viable counts of microorganisms alone may lead to erroneous conclusions about biofeasibility. Research has shown that viable counts may not represent the microbial population that is being sampled (Fry and Zia, 1982; Brock, 1987).

The site for the pilot demonstration project was therefore characterized to assess the feasibility of nitrate-enhanced bioremediation. The microbial ecology of the site and the biodegradation potential of BTEXTMB was determined. The microbial ecology was characterized by Michele Thomas, Cristin Bruce, Virginia Gordy, and others at Rice University, and has been published in detail elsewhere (Thomas et al, 1995; Thomas et al, 1997). The following section is a brief summary of their work, and includes enumeration of viable and direct counts, cell counts by phospholipid fatty acid (PLFA) determination, the most probable number (MPN) of total denitrifiers, MPN of JP-4 degrading microorganisms with nitrate as the electron acceptor, and aerobic and anaerobic protozoa. Biodegradation potential, as evaluated through treatability studies, is covered in Section IIC.

a. Methods

Subsurface material was collected at three depths from boreholes adjacent to Locations 80A, 80B, 80D, 80E, 80J, and 80K (Figure 5), and included the proposed area to be treated with nitrate (80AA, 80BA, 80DA and 80EB), a site downgradient of the contamination (80JB), and a site located outside the zone of residual JP-4 contamination and used as a background site (80KB) as shown in Figure 8. Core samples were collected aseptically under anaerobic conditions using a field glovebox as described previously (Leach et al, 1989). Samples were kept on ice in the field and shipped to RSKERL, where split samples were obtained under aseptic, anaerobic conditions for treatability tests at RSKERL. The cores were then shipped on ice to Rice University and stored at 5° C until used. Texture analysis of the subsurface materials was conducted by Law Engineering, Houston, TX. Chemical and biochemical analyses of the cores were conducted at RSKERL by ManTech Environmental Technology, using RSKERL standard operating procedures. These analyses included pH, ammonia-nitrogen ($\text{NH}_4\text{-N}$), combined nitrate/nitrite-nitrogen ($\text{NO}_3/\text{NO}_2\text{-N}$), total Kjeldahl nitrogen (TKN), orthophosphate (o-PO_4), total phosphate (tot-PO_4), total organic carbon (TOC), and phospholipid fatty acids (PLFA). The concentrations of BTEXTMB and JP-4 in the subsurface materials were determined using gas chromatography as described previously.

Microbial counts were conducted at Rice University. Serial dilutions of each sample were prepared in triplicate under aerobic conditions by aseptically adding 10 grams of subsurface material to dilution bottles that contained 95 mL of

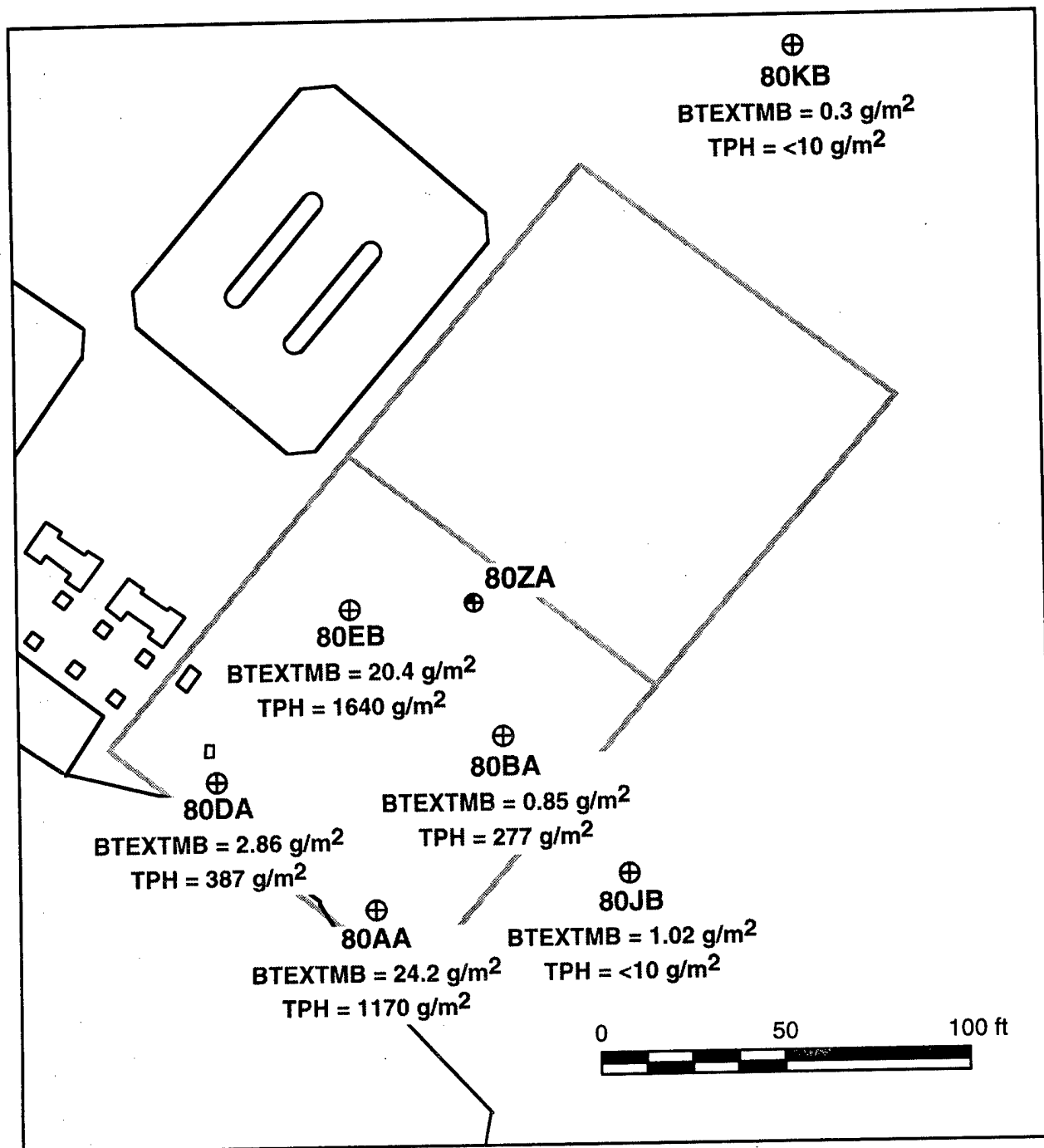


Figure 8. Location of Core Samples Taken for Microbial Characterization Prior to Remediation. Also Shown are Cumulative Masses of BTEXTMB and JP-4 for Given Locations.

0.1% sodium pyrophosphate. The bottles were shaken on a wrist action shaker for 1 hour, after which the rest of the dilution series was prepared using 0.1% sodium pyrophosphate as the diluent. This dilution series was used to determine the number of total heterotrophs, JP-4 degraders, oligotrophs, total denitrifiers, JP-4 degraders that use nitrate as the terminal electron acceptor, and aerobic and anaerobic protozoa in each sample. Acridine orange direct counts were determined on dilutions prepared by adding 2.5 grams of subsurface material in 22.5 mL of 0.1% sodium pyrophosphate and shaking for 1 hour. All plates and incubation vessels used to determine microbial numbers were incubated at room temperature (~25°C) in the dark.

Using the plate count technique, the number of total heterotrophs, JP-4 degraders, and oligotrophs that grew aerobically on R2A medium (Difco Industries, Detroit, MI), a mineral salts medium incubated in the presence of JP-4 vapors, and a mineral salts medium incubated without JP-4 vapors, respectively, was determined (Thomas et al, 1995). Although the proposed remedial treatment is anaerobic, counts of aerobic microorganisms are important; most denitrifiers are aerobic organisms that switch to anaerobic respiration in the absence of oxygen (Alexander, 1977). Colonies growing on R2A medium were counted after 1.5 to 2 weeks of incubation, whereas colonies growing on the other media were counted after 4 weeks of incubation. The MPN of total denitrifiers was determined using Nitrate Broth (Difco Industries).

The MPN of organisms that degrade JP-4 using nitrate as the electron acceptor was determined by first sterilizing 40-mL vials containing 20 mL of mineral salts medium amended with 1 g/L KNO_3 . Then, 200 μL of filter-sterilized JP-4 was added aseptically to the vials, after which the vials were inoculated with serial dilutions of the samples and sealed with Teflon®-lined septa and open top screw caps. Vials prepared identically, except without JP-4, were used as controls to assess denitrification from metabolism of ambient organic carbon. Because the vials containing JP-4 were initially aerobic, any denitrification detected could result from metabolism of oxygenated intermediates of JP-4 biodegradation and/or JP-4. The MPN of denitrifiers and the number of JP-4 degraders that use nitrate as the terminal electron acceptor were determined after 3 and 6 weeks, respectively. Denitrification potential was determined colorimetrically by testing for the presence of nitrite with sulfanilic acid and N,N-dimethyl-1-naphthylamine (Blazevic et al, 1973).

Direct counts of microorganisms were determined by epifluorescence microscopy (Wilson et al, 1983). The number of aerobic and anaerobic protozoa was determined (Sinclair and Ghorse, 1987) using subsurface sediment or dilutions of the sediment. Plates containing the protozoan enrichments were incubated aerobically or anaerobically in an anaerobic glovebox. The aerobic enrichments were observed at 2, 4, 6, and 8 weeks. The anaerobic enrichments were observed every 3 weeks for 3 months for cysts or vegetative protozoa. The Student's *t*-test for equal or unequal variances was used to compare microbial numbers in contaminated and uncontaminated zones.

b. Results

Core samples were composed of fine to medium-grained sands. Except for sample 80JB2 (86% sand), all samples consisted of at least 92% sand with the remainder being silt. The cores were slightly acidic, with high organic nitrogen and low nitrate (Table 7). TOC values were generally low, even where there was residual fuel contamination. JP-4 fuel was not detected in subsurface material from either the 80JB or 80KB boreholes; however, this does not mean that these locations had not previously been influenced by contamination. Sample 80KB6, for example, was believed to have been influenced at one time by a soluble BTEXTMB plume from this or another source, since analysis of subsurface material just below this depth at Location 80K indicated the presence of BTEXTMB (Appendix A). Although sample 80KB6 had no detectable BTEXTMB based on core analysis, the detection limit of 0.01 mg BTEXTMB/kg subsurface material is not low enough to detect low concentrations of BTEXTMB in the water.

Aquifer sediments at the site contain variable, but generally high, numbers of denitrifying bacteria, many of which can grow using constituents or breakdown products of JP-4 as carbon sources (Table 8). The MPN of total denitrifiers ranged from 10^4 to 10^7 , about the same as that observed in JP-4-contaminated aquifer material from Traverse City, MI (Hutchins et al, 1991b). Viable counts ranged from below detection to log 6 and direct counts ranged from log 10^7 to 10^9 , which is within the range observed for other subsurface materials (Ghiorse and Wilson, 1988; Kampfer et al, 1991). Although the number of microorganisms growing on a mineral salts medium in the presence of JP-4 vapor (JP-4 degraders) or without JP-4 vapor (oligotrophs) were about the same in many samples, the size of many colonies in the former were larger. Those microorganisms producing large colonies most likely were growing on the JP-4 whereas those producing small colonies may have grown on carbon impurities in the medium. Cell numbers estimated by phospholipid fatty acid analysis were usually less than, but positively correlated ($\alpha = 0.05$) to direct counts (Table 8).

Both aerobic and anaerobic protozoa were detected, suggesting that cropping of bacteria may occur during nitrate-enhanced bioremediation. Protozoa would limit the population size of the bacteria, thereby preventing biomass from clogging the treatment zone; however, cropping may decrease the rate of bioremediation by decreasing the number of hydrocarbon degrading microorganisms. Aerobic protozoa ranged from below detection to 10^6 , which is similar to that found at a site contaminated with aviation gasoline (Sinclair et al, 1993) but higher than that encountered at a site contaminated with coal tar (Madsen et al, 1991). Of interest was the detection of anaerobic protozoa at numbers equal to or less than 10^3 /gram dry weight. A flagellate determined to be a facultative anaerobe was isolated from sample

TABLE 7. CHEMICAL ANALYSES OF EGLIN AFB CORES, COLLECTED 3/93, PRIOR TO START OF REMEDIATION

Core Sample*	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bot int (ft MSL)	Int (ft)	pH (pH units)	NH ₄ -N (mg/kg)	NO ₃ /NO ₂ -N (mg/kg)	TKN (mg/kg)	o-PO ₄ -P (mg/kg)	tot-PO ₄ -P (mg/kg)	TOC (mg/kg)	BTEXTMB (mg/kg)	JP-4 (mg/kg)	PLFA (nM/g)
80AA2	2.3	3.4	7.7	8.8	1.1	5.80	2.4	<0.5	132.0	<0.5	47.2	0.123	0.061	214	2.97
80AA1	3.4	4.5	6.6	7.7	1.1	6.05	3.6	<0.5	103.0	<0.5	25.6	0.055	32.500	1290	1.37
80AA7	4.5	5.6	5.5	6.6	1.1	6.28	1.4	<0.5	64.2	<0.5	10.8	0.038	5.670	276	0.22
80BA3	1.0	2.2	8.7	9.9	1.2	5.61	1.4	<0.5	351.0	3.37	293.0	0.556	0.023	<10	3.50
80BA2	2.2	3.4	7.5	8.7	1.2	5.75	2.2	<0.5	197.0	2.49	195.0	0.260	0.597	355	4.20
80BA5	4.5	5.6	5.3	6.4	1.1	6.38	4.0	<0.5	84.0	1.05	32.2	0.091	0.245	<10	0.65
80DA1	2.5	3.5	8.8	9.8	1.0	4.94	0.9	<0.5	191.0	2.96	193.0	0.266	0.051	35	3.54
80DA5	4.0	5.0	7.3	8.3	1.0	5.82	2.6	<0.5	99.6	0.66	46.6	0.052	0.595	377	1.01
80DA8	6.0	6.8	5.5	6.3	0.8	6.21	<0.5	<0.5	75.6	0.74	19.8	0.009	0.043	55	0.55
80EB2	3.2	4.2	8.1	9.1	1.0	5.26	0.6	<0.5	161.0	<0.5	34.6	0.114	1.770	1160	1.26
80EB1	4.2	5.2	7.1	8.1	1.0	5.35	<0.5	<0.5	137.0	<0.5	43.6	0.103	31.000	1600	0.93
80EB5	6.5	7.5	4.8	5.8	1.0	7.02	<0.5	<0.5	75.4	<0.5	10.8	0.007	0.779	<10	0.21
80JB2	2.5	3.5	6.6	7.6	1.0	6.46	6.0	<0.5	144.0	1.86	58.6	0.169	0.691	<10	0.30
80JB1	3.5	4.5	5.6	6.6	1.0	6.93	6.2	<0.5	121.0	3.06	58.4	0.111	0.280	<10	0.41
80JB5	6.0	7.0	3.1	4.1	1.0	6.49	13.7	<0.5	147.0	3.84	121.0	0.077	NA	NA	0.09
80KB2	3.2	4.4	8.1	9.3	1.2	5.85	0.9	<0.5	92.4	<0.5	49.4	0.040	<0.001	<10	0.35
80KB1	4.4	5.5	7.0	8.1	1.1	6.36	0.6	<0.5	71.4	<0.5	15.2	0.016	<0.001	<10	0.18
80KB6	5.5	6.7	5.8	7.0	1.2	7.25	<0.5	<0.5	54.2	<0.5	7.0	0.005	<0.001	<10	0.06

* Core Locations 80AA, 80BA, 80DA, and 80EB were in areas still containing JP-4. Locations 80JB and 80KB were downgradient and upgradient, respectively.

**TABLE 8. NUMBERS OF DIFFERENT TYPES OF MICROORGANISMS IN EGLIN AFB
CORES PRIOR TO PILOT DEMONSTRATION PROJECT, COLLECTED 3/93**

Core Sample*	Low Intrvl (ft)	High Intrvl (ft)	Top Interval (ft MSL)	Bot Interval (ft MSL)	Int (ft)	Aerobic Plate Counts			Cell Count by PLFA Analysis Log cells/g	Cell Count by Direct Count Log cells/g (SD)
						Total Heterotrophs Log cells/g (SD)	JP-4 Degraders Log cells/g (SD)	Oligotrophs Log cells/g (SD)		
80AA2	2.3	3.4	7.7	8.8	1.1	6.7 (0.1)	6.6 (0.1)	6.6 (0.1)	8.5	9.0 (0.1)
80AA1	3.4	4.5	6.6	7.7	1.1	6.8 (0.2)	5.5 (0.1)	5.5 (0.2)	8.1	8.9 (0.1)
80AA7	4.5	5.6	5.5	6.6	1.1	4.7 (0.2)	2.4 (0.1)	<2.0	7.3	7.2 (2.3)
80BA3	1.0	2.2	8.7	9.9	1.2	5.7 (0.1)	4.5 (0.1)	3.7 (0.1)	8.5	8.9 (0.2)
80BA2	2.2	3.4	7.5	8.7	1.2	6.0 (0.1)	4.4 (0.2)	3.9 (0.1)	8.6	9.1 (0.1)
80BA5	4.5	5.6	5.3	6.4	1.1	4.4 (0.1)	3.6 (0.1)	3.6 (0.1)	7.8	7.5 (2.4)
80DA1	2.5	3.5	8.8	9.8	1.0	5.9 (0.0)	4.9 (0.1)	5.1 (0.1)	8.5	8.8 (0.1)
80DA5	4.0	5.0	7.3	8.3	1.0	5.9 (0.0)	3.8 (0.1)	3.4 (0.1)	8.0	8.5 (0.1)
80DA8	6.0	6.8	5.5	6.3	0.8	5.8 (0.1)	5.2 (0.1)	5.2 (0.1)	7.7	8.5 (0.2)
80EB2	3.2	4.2	8.1	9.1	1.0	6.8 (0.1)	5.7 (0.3)	6.2 (0.0)	8.1	8.4 (0.3)
80EB1	4.2	5.2	7.1	8.1	1.0	4.6 (0.1)	4.2 (0.1)	2.6 (1.9)	8.0	8.3 (0.4)
80EB5	6.5	7.5	4.8	5.8	1.0	5.6 (0.1)	5.7 (0.1)	5.8 (0.1)	7.3	8.4 (0.3)
80JB2	2.5	3.5	6.6	7.6	1.0	5.6 (0.1)	3.3 (0.1)	3.3 (0.1)	7.5	8.3 (0.3)
80JB1	3.5	4.5	5.6	6.6	1.0	6.6 (0.1)	6.3 (0.1)	6.3 (0.1)	7.6	8.3 (0.2)
80JB5	6.0	7.0	3.1	4.1	1.0	4.8 (0.1)	4.2 (0.1)	4.2 (0.0)	7.0	8.1 (0.2)
80KB2	3.2	4.4	8.1	9.3	1.2	5.8 (0.1)	4.2 (0.1)	4.2 (0.1)	7.6	8.5 (0.2)
80KB1	4.4	5.5	7.0	8.1	1.1	5.2 (0.0)	4.4 (0.0)	4.9 (0.1)	7.3	7.8 (1.5)
80KB6	5.5	6.7	5.8	7.0	1.2	5.9 (0.2)	3.5 (0.1)	3.2 (0.1)	6.8	8.1 (0.4)
Core Sample	Low Intrvl (ft)	High Intrvl (ft)	Top Interval (ft MSL)	Bot Interval (ft MSL)	Int (ft)	Denitrifier Cell Counts			Protozoa**	
						Total Log MPN/g (SD)	JP-4 Log MPN/g (SD)	No. JP-4 Log MPN/g (SD)	Aerobic Log cells/g (SD)	Anaerobic Log cells/g (SD)
80AA2	2.3	3.4	7.7	8.8	1.1	7.1 (0.4)	6.8 (0.2)	3.4 (0.0)	4.4 (0.2)	0.8 (0.2)
80AA1	3.4	4.5	6.6	7.7	1.1	7.2 (0.6)	6.4 (0.1)	<1	3.0, <1, <1	2.0 (0.1)
80AA7	4.5	5.6	5.5	6.6	1.1	4.2 (0.2)	3.2 (0.5)	<1	2.9 (0.1)	0.4 (0.0)
80BA3	1.0	2.2	8.7	9.9	1.2	5.2 (0.7)	1.6 (0.3)	1.9 (0.5)	6.2 (0.1)	2.7 (0.4)
80BA2	2.2	3.4	7.5	8.7	1.2	6.0 (0.4)	4.5 (0.2)	3.2 (0.1)	5.8 (0.4)	2.2 (0.4)
80BA5	4.5	5.6	5.3	6.4	1.1	4.3 (0.4)	2.9 (0.3)	<1	2.9 (0.5)	0.7 (0.6)
80DA1	2.5	3.5	8.8	9.8	1.0	6.5 (0.2)	3.9 (0.2)	2.5, 2.9, <1	5.7 (0.4)	>2, >2, 1.6
80DA5	4.0	5.0	7.3	8.3	1.0	6.1 (0.1)	4.1 (1.2)	1.6 (0.2)	6.0 (0.3)	<0, <0, 0.7
80DA8	6.0	6.8	5.5	6.3	0.8	6.3 (0.4)	5.6 (0.3)	<2	>4	1.6 (0.2)
80EB2	3.2	4.2	8.1	9.1	1.0	6.6 (0.6)	5.5 (0.9)	<1	2.3 (0.3)	0.9, <0, 1.0
80EB1	4.2	5.2	7.1	8.1	1.0	4.4 (0.9)	2.3 (0.5)	<1	2.7 (0.2)	<0
80EB5	6.5	7.5	4.8	5.8	1.0	6.4 (0.2)	5.1 (0.3)	<1	3.5 (0.1)	<0, 0.4
80JB2	2.5	3.5	6.6	7.6	1.0	4.7 (0.0)	3.7 (0.3)	<1	3.6 (0.7)	1.7 (0.2)
80JB1	3.5	4.5	5.6	6.6	1.0	7.1 (0.4)	6.0 (0.4)	<1	2.5 (0.2)	<0, 0.7, 1.0
80JB5	6.0	7.0	3.1	4.1	1.0	4.4 (0.2)	3.0 (0.2)	1.5, <1, <1	2.8 (0.4)	<0.0, <0, 1.4
80KB2	3.2	4.4	8.1	9.3	1.2	4.8 (0.2)	0.9 (0.2)	<1	3.2 (0.2)	1.4 (0.2)
80KB1	4.4	5.5	7.0	8.1	1.1	5.7 (0.4)	1.4 (0.7)	<1	<1	0.8 (0.2)
80KB6	5.5	6.7	5.8	7.0	1.2	5.3 (0.2)	2.0 (0.2)	<1	2.5 (0.2)	1.3 (0.7)

* Core locations 80AA, 80BA, 80DA, and 80EB were in areas still containing JP-4. Locations 80JB and 80KB were downgradient and upgradient, respectively

80DA1.

Population counts of the different types of microorganisms in the proposed treatment zone (cores 80AA, 80BA, 80DA, and 80EB), which is also the zone of residual fuel saturation, were statistically compared to those in the uncontaminated samples, 80KB2 and 80KB1, of the control core. Sample 80KB6 was not used as an uncontaminated control since it probably had been exposed to contamination as previously discussed. Microbial numbers were significantly higher in the proposed treatment zone than in the uncontaminated control samples, except for the number of oligotrophs, total denitrifiers, and an estimate of anaerobic protozoa ($\alpha = 0.05$). These data suggest that the biomass increased as a result of the contamination event. However, it is also possible that the previous remediation efforts using hydrogen peroxide and nutrient addition led to an increase in biomass and diversity. However, it is not known whether those effects would have been mitigated over time, whereas the remaining fuel components would have exerted a more pronounced effect. Other researchers have reported that contamination often increases biomass and biodegradation potential (Smith et al, 1986; Amand et al, 1989; Thomas et al, 1989). The high numbers of JP-4 degraders in the contaminated zone, and microorganisms that can use JP-4 under denitrifying conditions, suggest that these microorganisms have adapted to degrade the JP-4 fuel. In summary, characterization of the site indicated indigenous subsurface microorganisms were present and capable of degrading JP-4 jet fuel under denitrifying conditions, and that the site appeared to be amenable to nitrate-enhanced bioremediation.

7. Toxicity Evaluation

The pilot demonstration project provided a rare opportunity to evaluate toxicity associated with the contaminated sediments prior to initiating nitrate-based bioremediation, as well as to assess the degree of toxicity reduction (or increase) as a consequence of remediation. An initial attempt to evaluate toxicity was made by Rice University personnel using the Microtox and Mutatox assays to determine toxicity and mutagenicity of the core samples obtained for microbial characterization. Both assays rely on changes in bacterial luminescence when *Photobacterium phosphoreum* is exposed to toxins or mutagens. Dr. B. Thomas Johnson, National Fisheries Contaminant Research Center, Columbia, MO, conducted the assays. Using the Microtox assay, the only samples to exhibit toxicity were 80AA1 and 80EB1, which were the samples that contained the highest JP-4 concentrations (M. Thomas, personal communication). Therefore, these tests were not sensitive enough for detecting toxicity changes throughout the site as remediation progressed.

Because of this, a separate project was established with Jack Bantle from Oklahoma State University to evaluate other methods for assessing toxicity associated with contaminated sediments. The project goal was to develop and evaluate

reproductive and developmental toxicity tests using the gametes and embryos of the South African clawed frog *Xenopus laevis* with particular emphasis on assessing the toxicity of contaminated sediments from the pilot project demonstration area. This report has been published separately (Bantle, 1996). The following section describes the application of the basic FETAX assay to the pre-test core samples. FETAX (Frog Embryo Teratogenesis Assay- *Xenopus*) is a 4-day whole embryo developmental toxicity tests that utilizes the embryos of *Xenopus*. FETAX was initially designed as an indicator of potential human developmental health hazards. The assay is well suited for complex mixtures (e.g., industrial effluents etc.) testing and has been validated using single chemicals of known mammalian developmental toxicity (Bantle, 1996).

a. Methods

Ten locations were selected in the pilot demonstration area for toxicity assessment using FETAX (Figure 9). A large auger was used to drill down to approximately 0.5 feet above the desired interval. Two to four core barrels, depending on the amount of material needed, were then inserted into the hole and driven 3 feet into the subsurface. These were left in place until ready for sampling. Each core barrel was then pulled and extruded separately. The first one to three barrels were used to provide core material for OSU. For each core barrel, recovery of aquifer material was measured and the appropriate amount was extruded and discarded from the bottom of the barrel to attain the desired interval. The core was then extruded without paring into two clean pint jars to 4/5 capacity, afterwhich 100 mL of anaerobic CaCO_3 solution was added to each jar to begin pH stabilization. The final core barrel was used for BTEXTMB/TPH analyses to better define the hydrocarbon distribution. This core was extruded directly into four 1/2-pint jars, and subsamples were taken with 10-mL plastic syringes and extracted with MeCl_2 for analyses as described previously. All samples were mixed and stored in ice chests (without ice) in the shade prior to transport back to RSKERL. The samples were stored at 12°C and were picked up by OSU personnel the next day.

Initial experiments were conducted using FETAX to assess the developmental toxicity of JP-4. Because human effects were a concern, the initial tests were conduct with and without Aroclor 1254-induced rat liver microsomes to simulate mammalian metabolism. In the first experimental series, FETAX was used to determine the developmental toxicity of JP-4 emulsified in 2% agarose. This technique allowed the exposure of nonpolar organics in aqueous media. In later experiments, JP-4 was tested with corn oil, which was used to help disperse the jet fuel in agarose and would be used as a vehicle in other experiments. For the aquifer cores, two methods of exposure were attempted. The first method was aqueous extraction in which the cores were mixed with FETAX solution overnight at 30 rpm and then the sediment was removed by centrifugation. The embryos were then exposed to the water fraction. The second method was a direct soil exposure method performed by placing 50 cm³ of

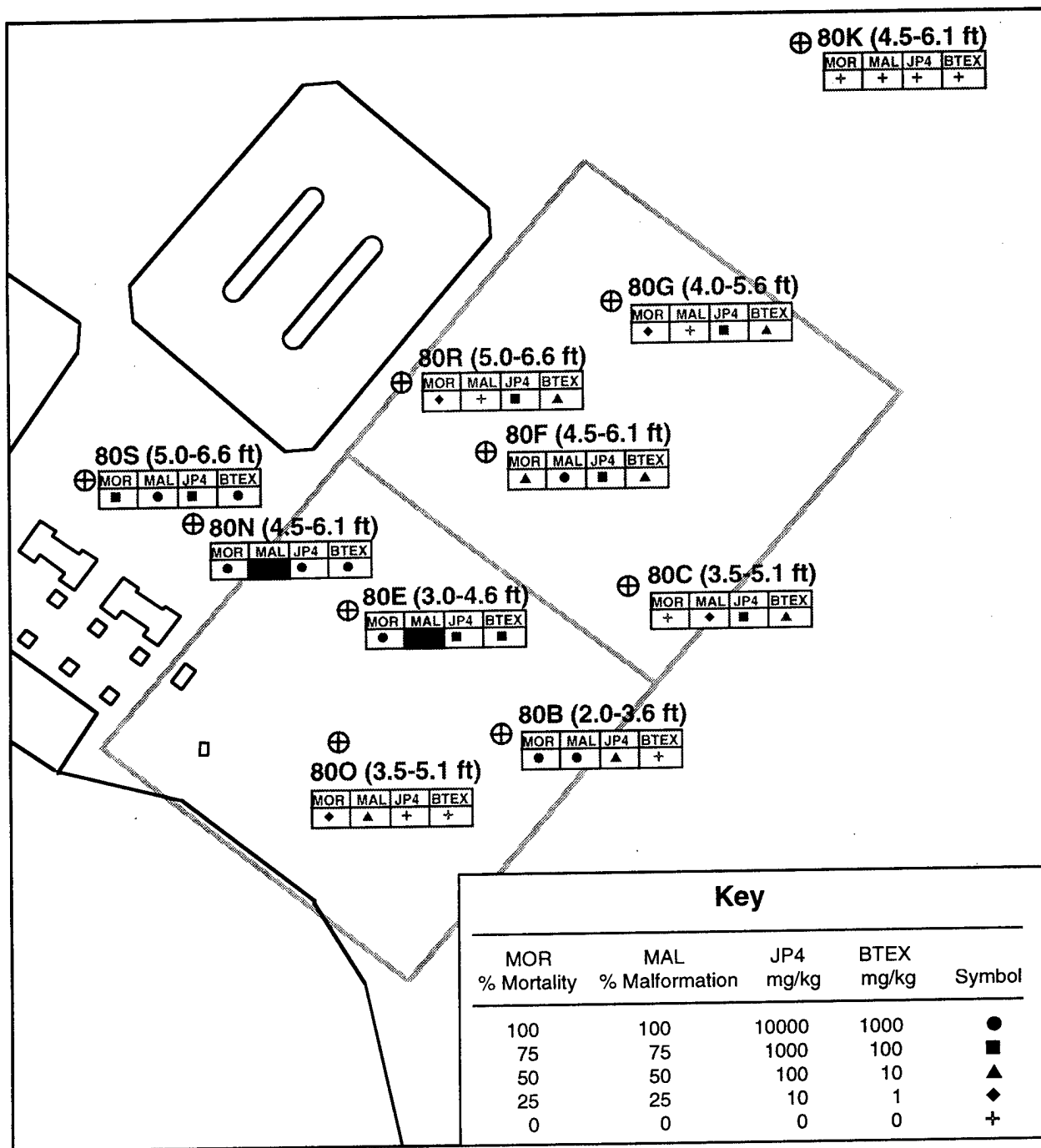


Figure 9. Location of Core Samples Taken for Toxicological Evaluation Prior to Pilot Demonstration Project, Showing Test Results and Contaminant Levels.

core sample in a vessel with 170 mL of FETAX solution and suspending the embryos above the sediment. As a control, sediment from Location 80K was spiked with JP-4 to determine if toxicity from JP-4 could be observed with the direct exposure method.

b. Results

The initial experiments with JP-4 were successful on several counts. The first experiments showed that it was possible to generate standard toxicity parameters (LC50, EC50, TI and MCIG) using the agarose exposure technique (Bantle, 1996). The tests with microsomes showed insignificant differences from the test without microsomes, indicating that cytochrome P450 did not significantly change the toxicity of JP-4. This did not mean that cytochrome P450 did not metabolize JP-4, but that developmental toxicity was unaltered. For the aquifer cores, the direct exposure method showed more severe effects than did the aqueous extraction exposure method for all sites (data not shown). Because mortality caused by 50 cm³ sediment samples was 100% for most sites, the sample size was reduced to 5 cm³ and all cores were retested. Previous studies with JP-4-spiked core and the amount of TPH present in the core samples had suggested that 50 cm³ would be required to obtain significant developmental toxicity. When 5 cm³ of sediment proved toxic, it suggested that additional toxicants were present in these cores or the JP-4 present in the sediment was metabolized over time to increase its toxicity. The control site 80K that was spiked with JP-4 also showed significant effects both at 50 cm³ and 5 cm³ of sediment direct exposure (data not shown).

A qualitative assessment of site toxicity was obtained by ranking the data from the various exposure groups. For example, direct exposures with 50 cm³ aquifer cores yielded the following ranking, in order of increasing toxicity, for mortality:

Exp1: 80K < 80G < 80R < 80B = 80O = 80S = 80N = 80E = 80F = 80C

Ranking of malformation on the sites for survivors from direct exposure to 50 cm³ aquifer cores are shown below:

Exp1: 80K < 80G < 80R

FETAX experiments using direct exposure with 5 cm³ core provide data on partial effects. Partial effects data will allow a determination of whether site developmental toxicity will be increased or decreased following nitrate remediation. The following is a ranking of the sites based on mortality results from direct exposure to 5 cm³ aquifer cores:

Exp1: 80E < 80G < 80K < 80R < 80F < 80C = 80B < 80N < 80O < 80S
Exp2: 80G < 80K < 80R < 80O < 80S < 80C < 80F < 80B = 80N = 80E
Exp3: 80G < 80K < 80R < 80O < 80F < 80C < 80B < 80S = 80N = 80E

Finally, the following is a ranking of sites based on malformation of survivors from direct exposure to 5 cm³ aquifer cores:

Exp1: 80K = 80O = 80G = 80C < 80R < 80E < 80F = 80B < 80N
Exp2: 80K < 80G < 80R < 80O < 80S = 80F = 80C
Exp3: 80R < 80G < 80K < 80O < 80F < 80C = 80B

In conclusion, the results from all of these experiments suggested that developmental toxicity of the site due to JP-4 can be measured using direct exposure to *Xenopus* embryos. These experiments also showed that was possible to rank the sites from most toxic to least toxic. Although there were some anomalies in the data, trends in the ranking of sites could be determined, with areas closer to the source (80N, 80E) being more toxic than areas further away (80K, 80C). This is shown schematically in Figure 9, which compares the overall toxicity based on the reduced data with the core locations and relative extent of contamination. These tests were later repeated following bioremediation to assess whether site toxicity had been reduced.

C. TREATABILITY STUDIES

Microbial counts alone are insufficient to assess process feasibility in terms of biodegradation potential. Treatability studies are also required, using microcosms to simulate field conditions as much as possible and varying the environmental parameters for sensitivity analysis. There is no defined procedure for determining how many samples are required to give an overview of microbial activity at a given site. Similarly, there is little consistency among researchers regarding microcosm construction, sampling, and analyses. Because no microcosm work had previously been done at this site to evaluate the potential for indigenous microbial populations to degrade BTEXTMB under denitrifying conditions, batch microcosm tests were conducted with numerous core samples to quantitate rates and extent of biodegradation. In addition, the effects of nutrient addition were examined in one core sample to determine whether nutrient supplements would be required in the pilot study. Finally, column studies were performed to validate results observed in batch tests and to see if denitrification would be affected by oxygen, expected to be incorporated into the sprinkler recharge.

1. Distribution of Microbial Activity and Nutrient Requirements

a. Methods

To evaluate distribution of nitrate-based BTEXTMB-degrading activity, core subsamples were split from the 18 core samples which had been collected for

Rice University (Figure 8). Microcosms were prepared aseptically in an anaerobic glovebox to preclude intrusion of oxygen. All preparations were made when the atmospheric oxygen concentration in the glovebox was less than 10 ppm (vol/vol) as measured by an oxygen monitor. Test chemicals were reagent-grade and all glassware and preparation supplies were sterilized. Dilution water, used to transfer core material, consisted of distilled water mixed with ground water from a spring near Ada, OK, to simulate the ground water at the Eglin AFB site. The dilution water was sterilized by autoclaving, transferred into the glovebox, and filtered through a 0.45 μ filter to remove precipitates. Microcosms were prepared by adding 10 g core material to 12-mL serum bottles. Core material was rinsed into the serum bottles using a small quantity of water and each sample was amended with nutrients to provide solution concentrations of 10 mg/L $\text{NH}_4\text{-N}$ and 10 mg/L $\text{PO}_4\text{-P}$. Microcosms were further amended with potassium nitrate to yield 50 mg/L $\text{NO}_3\text{-N}$. Poisoned controls also contained 250 mg/L mercuric chloride and 500 mg/L sodium azide as biocides to inhibit microbial growth. Sufficient viable and control microcosms were prepared to provide six to eight sampling events of three viable and one control microcosm per set. To evaluate nutrient demand, microcosms were prepared as above, with the following exceptions: (1) only one core sample was evaluated (a 50:50 mix of 80AA1 and 80AA2), and (2) different levels of nutrients were added. The following treatment groups were designated and included either: (1) no nutrients, (2) 10 mg/L $\text{NH}_4\text{-N}$ only, (3) 10 mg/L $\text{PO}_4\text{-P}$ only, or (4) 10 mg/L each $\text{NH}_4\text{-N}$ and $\text{PO}_4\text{-P}$. In addition, a separate control group was established to provide three replicate control microcosms per set.

Each microcosm was then spiked with an aqueous stock containing benzene, toluene, ethylbenzene, *p*-xylene, *m*-xylene, *o*-xylene, mesitylene, pseudocumene, and 1,2,3-trimethylbenzene to yield final solution concentrations of 1 to 6 mg/L for each compound. Immediately after spiking, the microcosms were sealed without headspace using Teflon®-lined butyl rubber septa, mixed, inverted, and incubated in an anaerobic glovebox in the dark at 20°C. Three replicates from each viable set and one to three control microcosms, depending on the test, were sacrificed at designated time intervals. Each microcosm was mixed and centrifuged at 1500 rpm for 30 minutes to clarify the supernatant. Aqueous volatile aromatic hydrocarbons were analyzed by purge-and-trap gas chromatography using a Tekmar LSC-2000 liquid sample concentrator and an HP5890 GC with a flame ionization detector. Hydrocarbons were purged onto a Tenax trap for 6 minutes at 34°C followed by a 2-minute dry purge and desorbed for 4 minutes at 180°C. Samples were chromatographed using a 30-m x 0.53-mm ID megabore DB-wax capillary column with a 1.0- μ m film thickness. The temperature program was from 50°C (4 minutes) to 120°C at 8°C/minute, and then to 180°C at 30°C/minute. The quantitation limit for these compounds was 0.2 μ g/L. The remaining aqueous sample was analyzed for pH, nitrate, nitrite, ammonia, and phosphate using standard EPA methods as described previously (Kopp and McKee, 1979). The residual solids were not analyzed.

b. Results

As shown by the example data for Core 80EB5, selected alkylbenzenes were degraded under denitrifying conditions by indigenous aquifer microorganisms at the site, with toluene, ethylbenzene, and *m*-xylene typically being preferred over the other alkylbenzenes (Figure 10). Biodegradation of *p*-xylene, *o*-xylene, mesitylene, and pseudocumene was generally intermediate, whereas benzene and 1,2,3-trimethylbenzene were often recalcitrant. Removals of each compound were calculated over the 28-day time period, corrected for corresponding loss (or gain) in controls, and graphed to show distribution of microbial activity (Figure 11). The extent of removal for the different compounds was surprisingly variable across the site and did not always correlate with either depth or extent of contamination. For example, in the area of residual JP-4 contamination within the nitrate cell (80AA, 80BA, 80DA, 80EB), the highest amount of JP-4 (1600 mg/kg) was found in the mid-depth core within the 80EB series (Table 7). This core also contained the lowest amounts of hydrocarbon removal activity in this group (Figure 11), and thus the results might be attributable to toxicity of residual JP-4. However, the shallowest cores of the 80AA and 80EB series had the next highest levels of JP-4 (1290 and 1160 mg/kg, respectively) and hydrocarbon removal was better there than in several of the others with lower JP-4 levels (Figure 11). Also, the downgradient location 80JB exhibited the least amount of hydrocarbon removal, even though it was relatively clean (Figure 11, Table 7). In contrast, the greatest extent of hydrocarbon removal was found in another clean sample, the deepest core of the 80KB series (Figure 11). However, as previously mentioned, core samples below this depth at this location show increasing BTEXTMB contamination, probably as a result of contamination up-gradient.

It should be emphasized that these data do not conclusively demonstrate biodegradation of these compounds under denitrifying conditions, even though poisoned controls were successfully used. Previous work has shown that abiotic removals of some compounds (such as benzene) are enhanced when labile substrates (such as toluene) are metabolized under denitrifying conditions, possibly in response to enhanced sorption due to the production of biomass or other metabolites (Hutchins, 1993). However, the different patterns of compound removal observed in these different locations strongly suggest that biodegradation is primarily responsible. In addition, the period of alkylbenzene removal generally coincided with the periods of nitrate removal and nitrite production (data not shown). Total combined BTEXTMB removals ranged from 12-50% for Location 80AA, 57-74% for Location 80BA, 38-60% for Location 80DA, 5-72% for Location 80EB, 0-1% for Location 80JB, and 7-81% for Location 80KB. Total nitrate removals ranged from 21-52% for Location 80AA, 34-43% for Location 80BA, 18-90% for Location 80DA, 29-86% for Location 80EB, 5-11% for Location 80JB, and 16-34% for Location 80KB. Nitrate removal did not correlate with BTEXTMB removal in the area within the Nitrate Cell ($r^2 = 0.008$, $P = 0.608$, 36 observations), presumably because of the different amounts of residual hydrocarbon within this area (Table 7). However, a significant linear correlation ($r^2 = 0.836$, $P =$

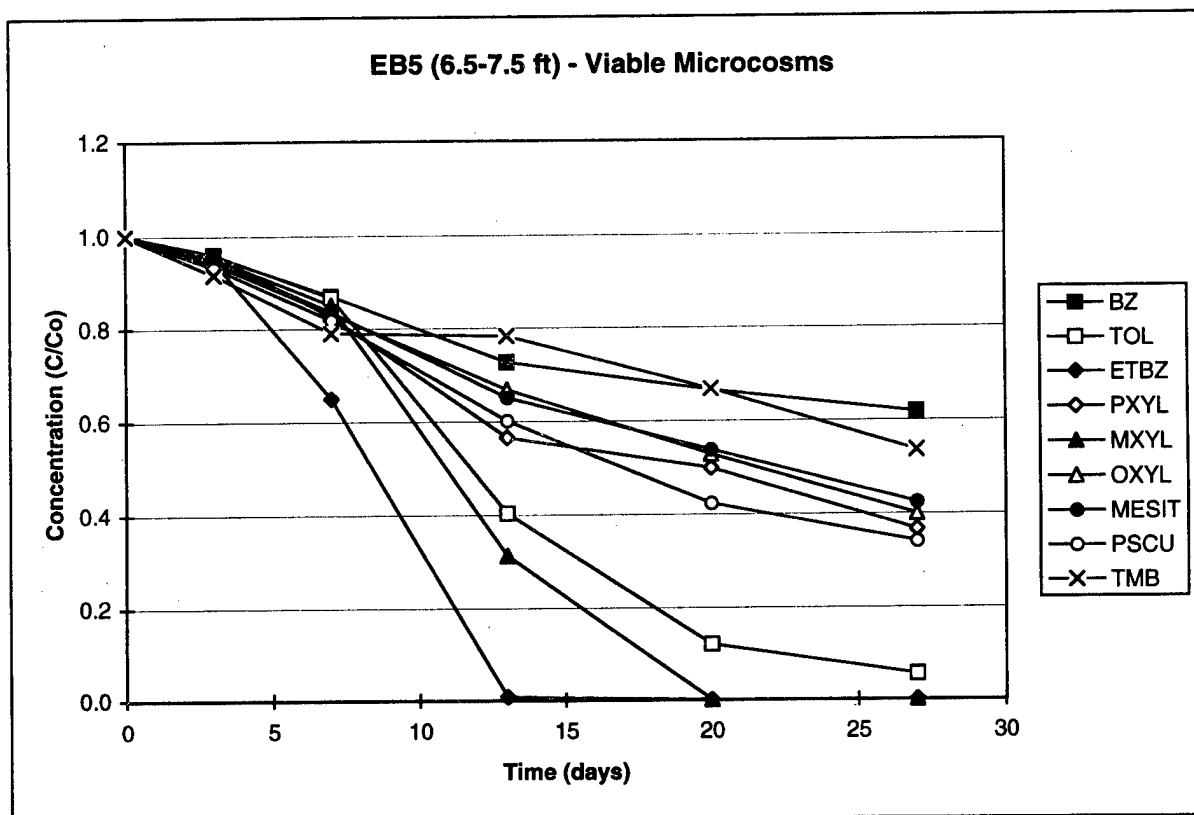
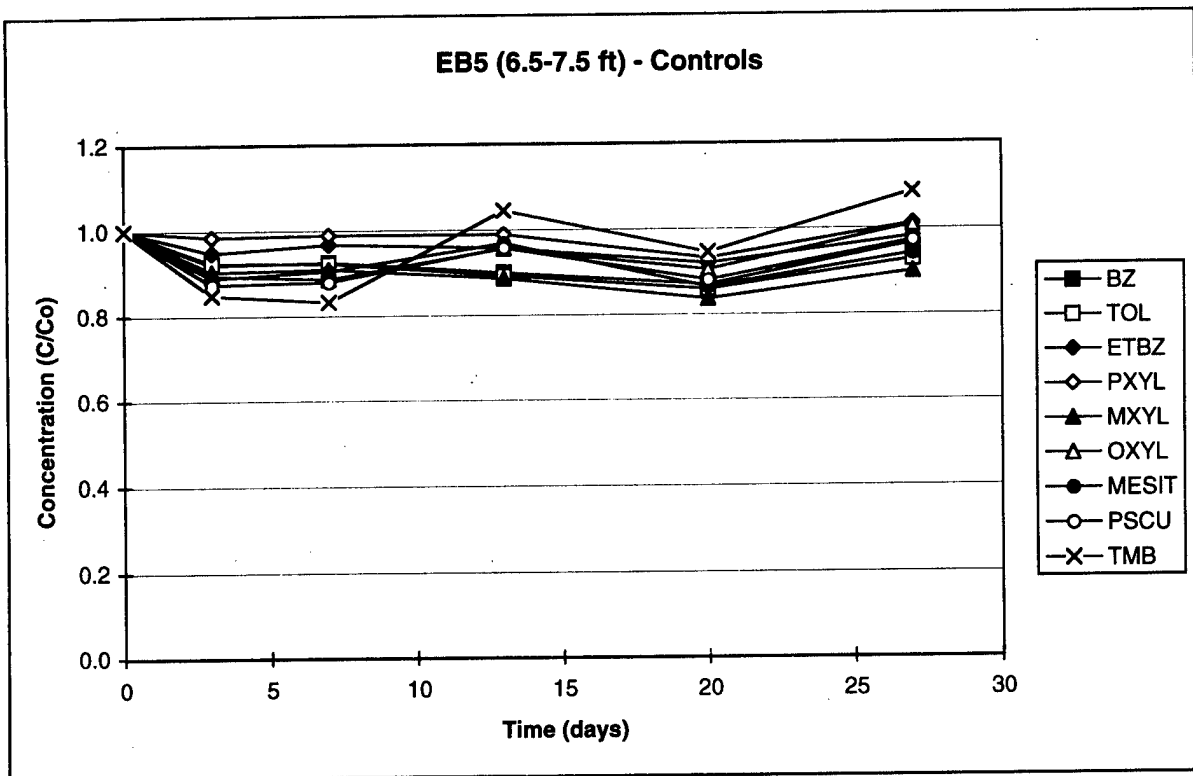


Figure 10. Removal of Individual BTEXTMB Compounds Under Denitrifying Conditions at Location 80EB5, Prior to Start of Remediation.

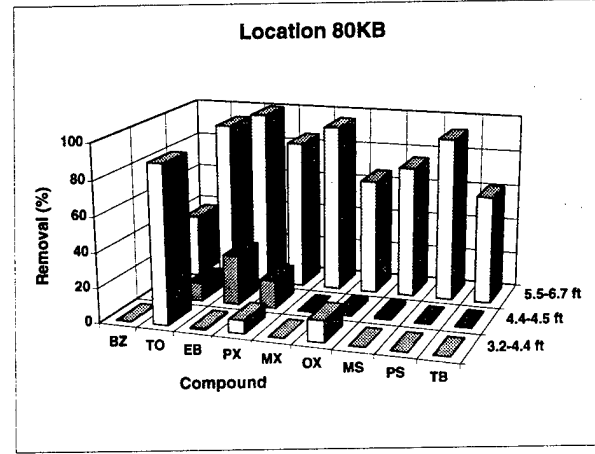
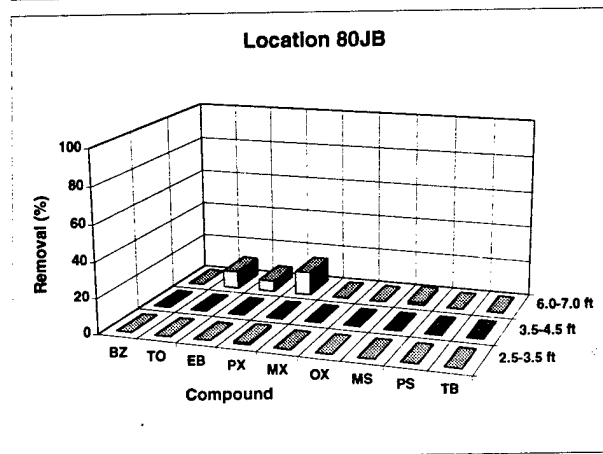
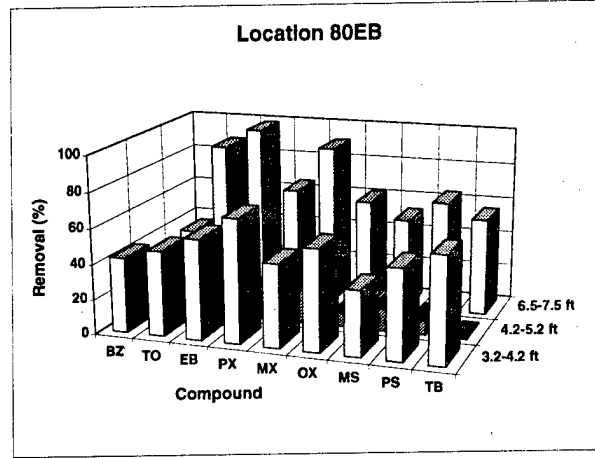
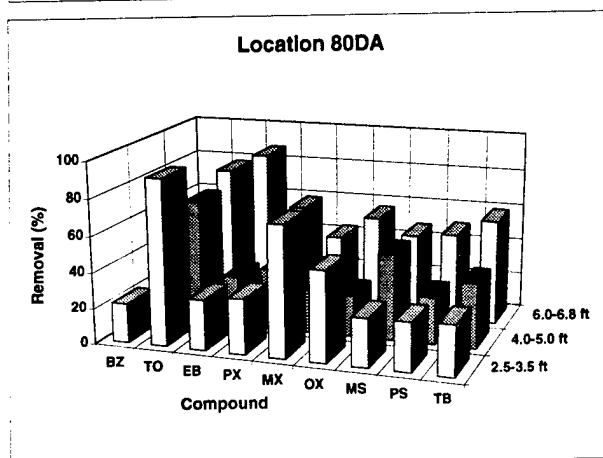
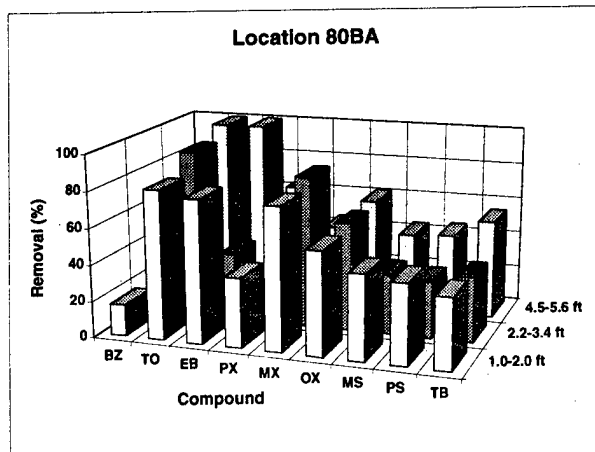
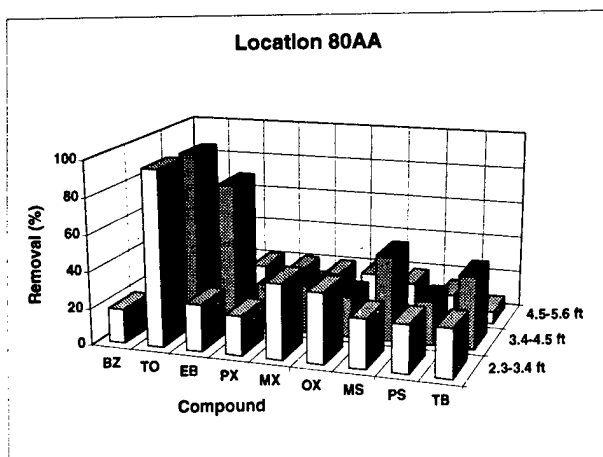


Figure 11. Percent Removal of BTEXTMB Compounds in Pre-Test Cores After 28 Days Under Denitrifying Conditions. Removals are Corrected for Loss in Controls; Negative Removals are Shown as Zero. Mean of Three Replicates Per Set.

0.0006, 9 observations) was obtained between BTEXTMB removal and nitrate removal for the three depths at control site 80KB, again strongly suggesting that biodegradation is primarily responsible for BTEXTMB removal. This high correlation probably results from the low TOC at this location, enabling the BTEXTMB spike to be used exclusively as the electron donor.

Concentrations of individual alkylbenzenes in viable and control microcosms were totaled and graphed to provide summary data on the biodegradation of combined BTEXTMB as a function of sample location and depth (Figure 12). Overall, microbial activity was observed in 12 of the 18 separate core samples. Five of the inactive samples were from regions outside of the proposed treatment zone and contained no discernable JP-4 contamination. For the active samples, the mean zero-order rate constants were 1.2 ± 0.5 mg/L/day alkylbenzene biodegradation and 2.6 ± 1.3 mg/L/day $\text{NO}_3\text{-N}$ removal. Addition of either ammonia-nitrogen, phosphate-phosphorus, or both had little effect on the rate of either BTEXTMB biodegradation or nitrate utilization (Figure 13). There was a slight increase in the extent of denitrification when ammonia-nitrogen was added as a sole amendment, but the effect was minor. This indicates that nutrient addition might not be required for enhancing denitrification in the field at this site. However, extrapolation of batch microcosm data may be insufficient for predicting long-term field requirements, and so monitoring aqueous nutrient levels in the field during pilot operation would be recommended.

In summary, these data indicated that nitrate-based bioremediation was feasible for this site, and that the requisite microbial activity was distributed throughout the proposed treatment region. However, the rates of alkylbenzene removal and nitrate consumption were lower than observed at other field sites (Hutchins et al, 1991b; Hutchins and Wilson, 1994). There are many factors which can affect the endogenous rates of denitrification at this site, including microbial population diversity, pH, toxicity of fuel constituents, and availability of suitable electron donors. However, no experiments were conducted to delineate which of these controlling parameters had the greatest effect on the groups of microorganisms which degrade BTEXTMB under denitrifying conditions. We suspect that the low pH was somewhat inhibitory, since denitrifying bacteria prefer pH-neutral or slightly alkaline soils (Tiedje, 1988). However, we did not consider pH modification in the experimental design of the pilot demonstration project because of previous concerns with soil plugging and loss of infiltration capacity. Regardless, the observed low endogenous rates of nitrate reduction would preclude any advantage of applying nitrate in excess of 10 mg/L $\text{NO}_3\text{-N}$. This would also avoid the use of high flow rates, so sufficient residence time could be afforded for microbial reactions to proceed as recharge water migrates down-gradient from the pilot test site.

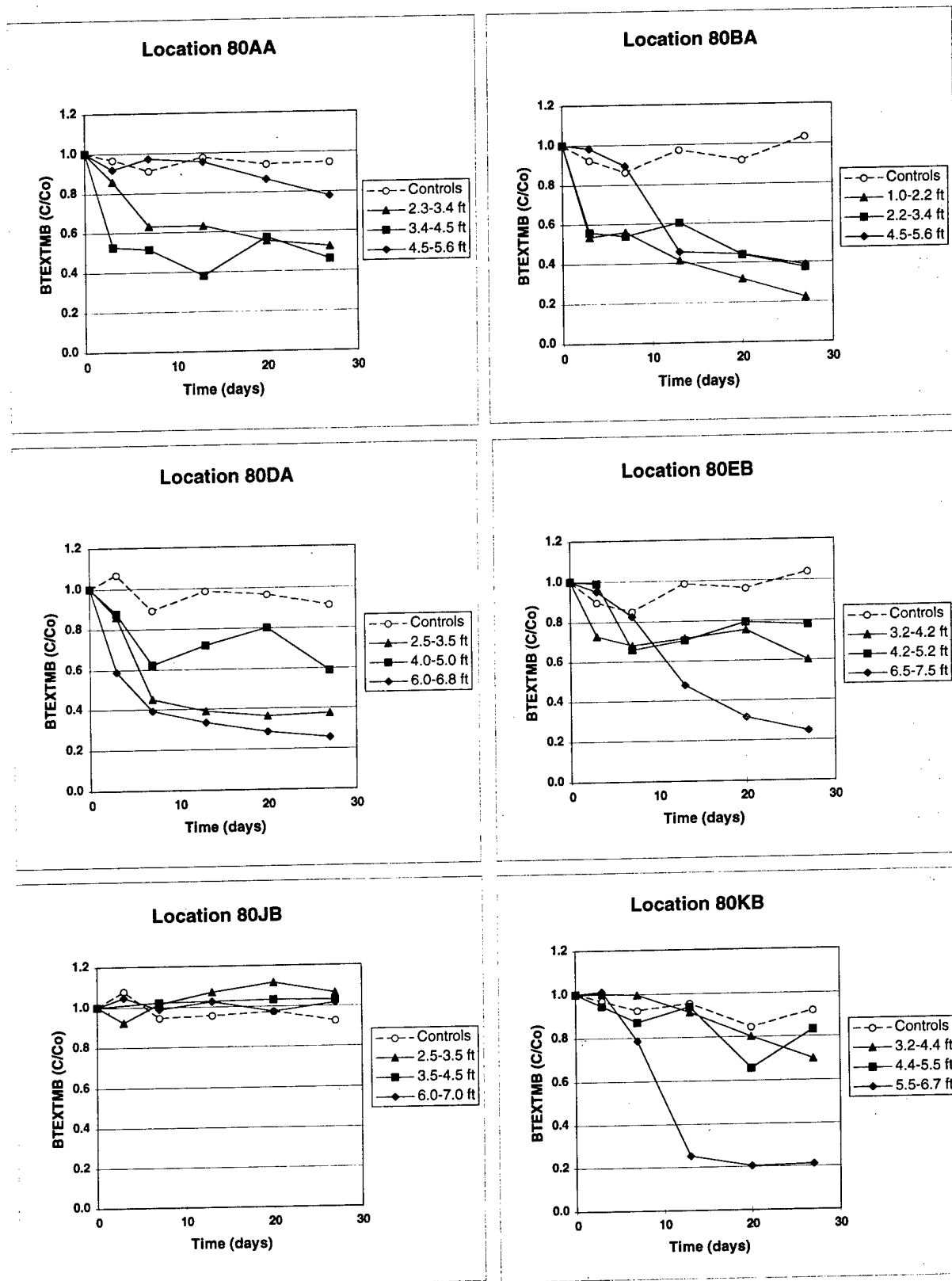


Figure 12. Microcosm Study on Combined BTEXTMB Removal, Under Denitrifying Conditions, in Cores Taken from Pilot Demonstration Area Prior to Remediation. Mean of Three Replicates Per Set.

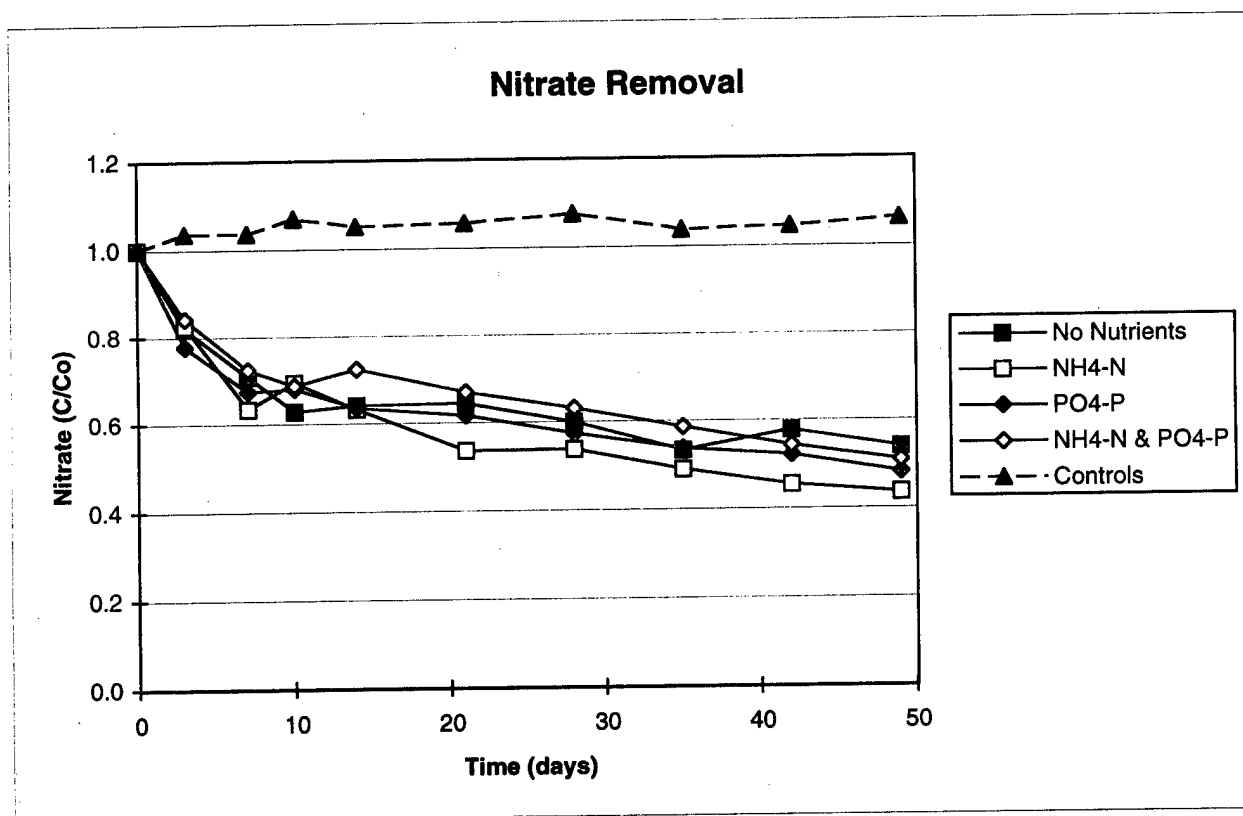
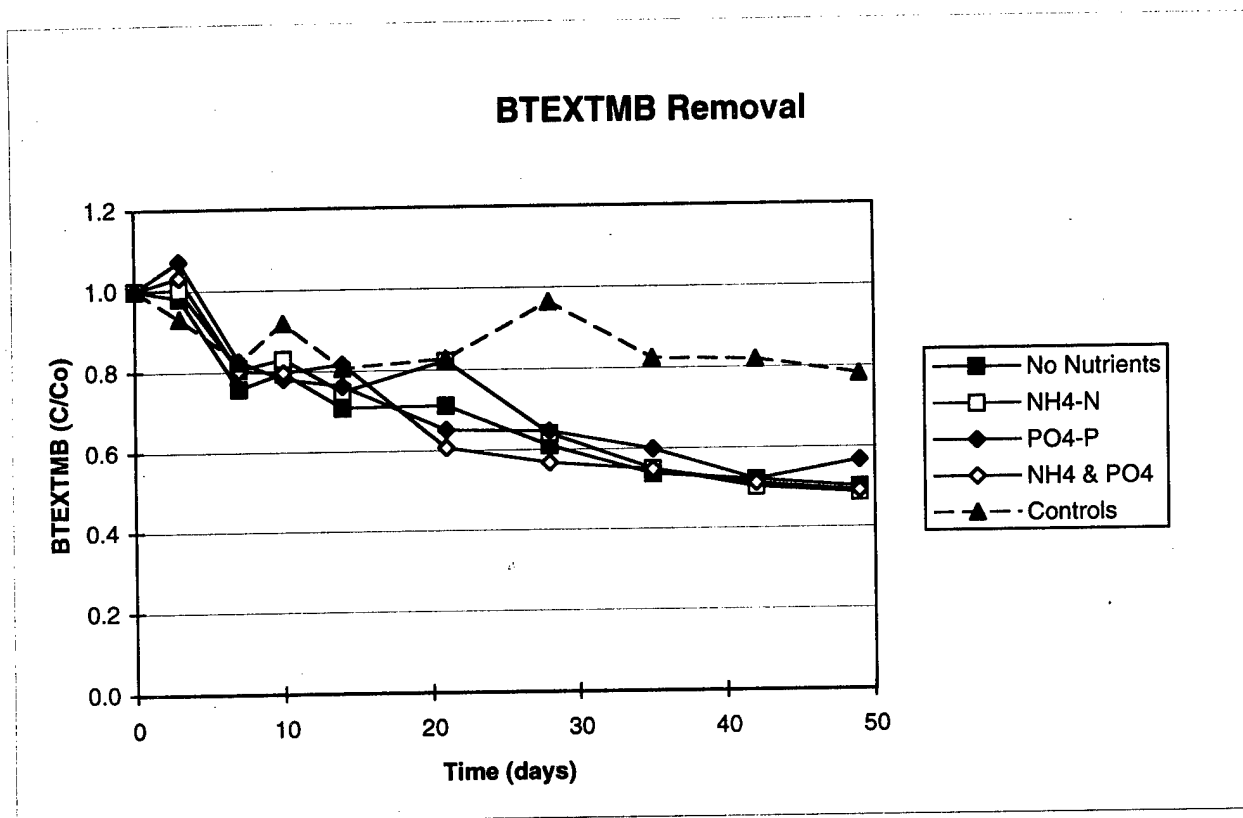


Figure 13. BTEXTMB and Nitrate Removal in Denitrifying Microcosms with Selected Nutrient Amendments. Mean of Three Replicates Per Set.

2. Mineralization Studies

a. Methods

Because of the questions regarding the role of mineralization versus other processes (eg, partial biodegradation, enhanced sorption), microcosm tests were conducted with radiolabeled compounds to assess the extent of biodegradation in the Eglin AFB aquifer material. At this time, fresh aquifer material was not available, and so mineralization studies were conducted with radiolabeled *m*-xylene on replicate microcosms remaining from an initial test. However, mineralization occurred in only a few of these samples (unpublished data), and these results were considered suspect because of the extended time periods between the tests. Although the reason for this problem was not ascertained, it is possible that the extended incubation time resulted in a loss of the requisite microbial activity. More extensive tests were therefore conducted on fresh aquifer material collected during the Interim Performance Evaluation (described later). This material was collected 3.4-7.0 feet below ground surface at Location 80ZA, within the Nitrate Cell (Figure 8). The following radiolabeled compounds (Sigma) were used as supplied: [UL-¹⁴C]benzene (19.3 mCi/mmol), [ring-UL-¹⁴C]toluene (10.2 mCi/mmol), *m*-[ring-UL-¹⁴C]xylene (5.1 mCi/mmol), and *o*-[ring-UL-¹⁴C]xylene (9.0 mCi/mmol). Isotope purities exceeded 98 percent in all cases. Isotopes were diluted in the respective unlabeled compounds and individual aqueous spikes were prepared anaerobically as previously described. Microcosms were prepared as described for the initial batch studies, except that 10 grams aquifer material were used in 60-mL serum bottles to provide a larger aqueous volume for repetitive sampling. Final concentrations ranged from 1-2 mg/L for the individual radiolabeled compounds, with 30 mg/L NO₃-N, 10 mg/L NH₄-N, and 10 mg/L PO₄-P. Three replicate microcosms, with corresponding poisoned controls, were prepared for each of the four radiolabeled compounds. In addition, positive controls were prepared for each radiolabeled compound by constructing identical microcosms without nitrate addition. All microcosms were incubated at room temperature in an anaerobic glovebox.

All sampling was done in the glovebox. Microcosms were mixed and allowed to settle for several hours prior to sampling. For each microcosm, the septum was removed and aqueous samples were obtained using glass syringes. The removed volume was replaced using sterile 6-mm glass beads and the microcosm was resealed without headspace, mixed, and incubated in the dark. BTEXTMB and nutrient analyses were conducted as previously described. Distribution of the radiolabel was assessed using a modification of the procedure used by Grbic-Galic and Vogel (1987). It should be noted that this assay accounts for distribution of the radiolabel in the aqueous phase alone, and represents the extent of biodegradation of available soluble substrate. Because of the large amount of solids present, and the continuous addition of glass beads to compensate for volume displacement, it was not possible to obtain reproducible and accurate counts of the solids. Three different

measurements were done on each sample. For total ^{14}C activity, 0.5 mL sample were injected directly into a mixture of 10 mL Beckman Ready-Value scintillation cocktail and 0.5 mL 1 N NaOH. This serves to contain the radiolabeled parent compound, as well as $^{14}\text{CO}_2$ and nonvolatile intermediates of metabolism. Next, 0.5 mL sample were injected into 0.5 mL NaOH. This was purged with nitrogen gas at 250 mL/min for 5 minutes, followed by the addition of 10 mL scintillation cocktail. This measurement represents both $^{14}\text{CO}_2$ and nonvolatile intermediates. Finally, 0.5 mL sample were injected into 0.5 mL 1 N HCl and similarly purged. This represents the nonvolatile intermediates only, and $^{14}\text{CO}_2$ was calculated by the difference between this sample and the NaOH-treated sample. All samples were allowed to equilibrate for at least 16 hours to minimize the effects of chemiluminescence, and were counted using a Beckman LS 7800 scintillation counter with automatic quench correction. The counting efficiency was 92%. Quality control check standards were run weekly, and blanks were prepared with 0.5 mL dilution water in both acid and base treatment vials.

b. Results

Data from the radiolabel microcosm test are summarized in Table 9, and show that biodegradation of toluene and *m*-xylene occurs when nitrate is added as the electron acceptor, but not in the absence of nitrate or in poisoned controls. After 21 days, 53% of the toluene was mineralized, with 12% remaining as nonvolatile intermediates or end-products. Thus, only 65% of the toluene was theoretically transformed. However, gas chromatographic analysis of the microcosm supernatants show 100% toluene removal (Table 9). Because both analyses are done on the microcosm supernatant only, sorption onto the sediment fraction do not account for the missing radiolabel. It is possible that toluene was converted to a volatile metabolite that was lost during purging of both the acid and base fractions during the analysis. However, this could also represent preferential incorporation of toluene into biomass or sorption onto suspended solids.

In other studies, Swindoll et al (1988) observed that uptake into cell biomass represented a large fraction of total metabolism for many xenobiotic compounds under aerobic conditions, and Jorgensen et al (1991) reported that 44% of labelled toluene was incorporated into biomass of enrichment cultures under denitrifying conditions. In contrast to toluene, 98% of the *m*-xylene label was recovered in this study, with 85% being mineralized and 13% remaining as nonvolatile intermediates or end-products. For all practical purposes, benzene was recalcitrant in this test under these conditions, despite a very slight amount of mineralization under denitrifying conditions compared with both the viable and poisoned controls (Table 9). Benzene was not expected to be a problem for this particular field site, because there was very little of it in the weathered fuel, except for the source area and in deeper wells outside of the treatment cells (Table 2, Appendix C). Although *o*-xylene was also recalcitrant in this test, this does not necessarily indicate that it was recalcitrant in the

TABLE 9. MINERALIZATION OF RADIOLABELED SUBSTRATES IN EGLIN AFB MICROCOSMS PREPARED WITH MID-TEST CORE MATERIAL. MEAN OF THREE REPLICATES WITH STANDARD DEVIATION

Compound	Parameters	Time	No Nitrate Added	Nitrate Added	Poisoned Controls
		(days)	Mean \pm StDev	Mean \pm StDev	Mean \pm StDev
Benzene	Concentration by GC (mg/L)	0	2.01 \pm 0.53	1.45 \pm 0.07	1.52 \pm 0.05
		7	1.47 \pm 0.20	1.61 \pm 0.15	1.57 \pm 0.16
		21	1.75 \pm 0.21	1.61 \pm 0.10	1.74 \pm 0.22
	Percent in Nonvolatile Carbon	0	0.22 \pm 0.17	0.04 \pm 0.06	0.18 \pm 0.16
		7	0.11 \pm 0.17	0.11 \pm 0.08	0.12 \pm 0.11
		21	0.02 \pm 0.03	0.29 \pm 0.41	0.02 \pm 0.03
	Percent Mineralized	0	0.52 \pm 0.02	0.39 \pm 0.03	0.16 \pm 0.23
		7	-0.05 \pm 0.07	0.25 \pm 0.10	-0.05 \pm 0.14
		21	0.79 \pm 0.12	1.88 \pm 0.47	0.27 \pm 0.06
Toluene	Concentration by GC (mg/L)	0	1.49 \pm 0.54	1.13 \pm 0.11	1.13 \pm 0.06
		7	1.37 \pm 0.07	1.12 \pm 0.17	1.48 \pm 0.23
		21	1.79 \pm 0.67	0.00 \pm 0.00	1.47 \pm 0.17
	Percent in Nonvolatile Carbon	0	1.22 \pm 0.20	1.64 \pm 0.39	0.93 \pm 0.19
		7	1.59 \pm 0.41	4.92 \pm 0.99	1.13 \pm 0.34
		21	1.60 \pm 0.20	11.8 \pm 1.97	1.03 \pm 0.07
	Percent Mineralized	0	0.39 \pm 0.18	0.89 \pm 0.31	0.21 \pm 0.28
		7	-0.07 \pm 0.56	7.99 \pm 2.66	-0.05 \pm 0.27
		21	0.58 \pm 0.11	53.0 \pm 4.10	0.08 \pm 0.07
<i>m</i> -Xylene	Concentration by GC (mg/L)	0	1.11 \pm 0.08	6.15 \pm 4.51	4.14 \pm 4.91
		7	1.38 \pm 0.19	1.41 \pm 0.10	1.55 \pm 0.11
		21	1.49 \pm 0.44	0.00 \pm 0.00	1.38 \pm 0.26
	Percent in Nonvolatile Carbon	0	5.70 \pm 0.59	5.29 \pm 2.09	4.14 \pm 0.55
		7	7.81 \pm 0.67	3.10 \pm 0.16	4.59 \pm 0.39
		21	5.68 \pm 1.07	12.9 \pm 0.84	3.85 \pm 1.71
	Percent Mineralized	0	1.15 \pm 0.61	1.39 \pm 3.18	-0.37 \pm 0.80
		7	-1.46 \pm 0.54	4.60 \pm 0.86	-0.87 \pm 0.71
		21	2.52 \pm 1.39	84.6 \pm 5.45	-0.12 \pm 1.01
<i>o</i> -Xylene	Concentration by GC (mg/L)	0	2.02 \pm 0.98	6.26 \pm 0.20	6.76 \pm 1.23
		7	2.51 \pm 0.22	2.44 \pm 0.53	2.01 \pm 0.38
		21	2.23 \pm 0.40	2.19 \pm 0.16	2.12 \pm 0.08
	Percent in Nonvolatile Carbon	0	3.53 \pm 0.19	4.21 \pm 0.45	2.97 \pm 0.33
		7	4.25 \pm 0.56	4.24 \pm 0.81	2.72 \pm 0.12
		21	4.06 \pm 0.77	3.51 \pm 0.74	2.39 \pm 0.23
	Percent Mineralized	0	0.16 \pm 0.36	-0.35 \pm 0.16	-0.37 \pm 0.59
		7	-0.25 \pm 0.35	-0.14 \pm 0.76	-0.35 \pm 0.40
		21	0.43 \pm 0.72	0.39 \pm 0.70	-0.26 \pm 0.06

previous microcosm studies. Other labile substrates were not added to these microcosms, and previous work has shown that the addition of other substrates often promotes biodegradation of *o*-xylene through cometabolic reactions (Jorgensen and Aamand, 1991; Evans et al, 1991; Hutchins, 1993). In summary, these data provide additional evidence that some of the removals observed in the previous tests could be attributed to biodegradation, indicating the feasibility of nitrate-based bioremediation.

3. Column Studies

The batch treatability studies provided a level of confidence regarding the feasibility of initiating nitrate-based bioremediation at the field site. To verify that nitrate-based biodegradation of BTEXTMB could operate under a mode of continuous operation, column studies were initiated. These column studies were performed not only to validate results observed in batch tests, but to see if denitrification would be affected by oxygen, expected to be incorporated into the sprinkler recharge. Tests were conducted with Eglin AFB aquifer material as well as aquifer material collected from two other sites. This work has been published in detail elsewhere (Miller and Hutchins, 1995), and the following is a brief summary of the results with the Eglin AFB material.

a. Methods

Glass columns, 3.8 cm ID and 30.5 cm in length, were assembled and operated within an anaerobic glovebox. The columns were configured to operate in an upflow mode, and all associated inlet and effluent lines were constructed of stainless steel tubing. Core samples 80AA3 and 80AA6, which were collected from 1.2-2.3 feet and 5.6-6.7 feet below ground surface, respectively, during the microbial characterization study (Figure 8) were combined and used to provide the aquifer material for the Eglin AFB column. Sediments were packed into the column to a height of 25.4 cm. Aqueous flowrates were used that corresponded to a residence time within the soil matrix of approximately 24 hours. The target compounds consisted of benzene, toluene, ethylbenzene, *m*-xylene, and *o*-xylene (BTEX), which were contained in a hexadecane solution and slowly partitioned into the column influent. Initially, the BTEX mixture was introduced into the soil column with no accompanying electron acceptor (no nitrate or oxygen) to allow sorption/desorption processes to stabilize. In addition to monitoring the inlet and outlet BTEX concentrations, column streams were monitored for dissolved oxygen to ensure that anaerobic conditions were maintained. Nitrate addition was initiated after complete breakthrough was observed for the compounds. Changes resulting from the nitrate addition were monitored until a stable concentration of BTEX compounds was observed the outlet stream. A low concentration of oxygen was then incorporated into the inlet stream, and monitoring of the BTEX concentrations was continued.

b. Results

Steady-state breakthrough of BTEX was achieved in about 50 days, after which nitrate was added and the column was operated for 57 days, and then for an additional 60 days with oxygen added as well. The data were averaged over the respective operating periods to provide an estimate of column performance. After steady-state breakthroughs were achieved, application of 26.1 mg/L $\text{NO}_3\text{-N}$ to the Eglin AFB column resulted in removal of BTEX components similar to removals previously observed in the Park City and the Traverse City soil columns (Miller and Hutchins, 1995). As summarized in Table 10, toluene seemed to be the most readily utilized, followed by *m*-xylene and ethylbenzene, with a slight removal of *o*-xylene and benzene. The slight removal of benzene was observed prior to nitrate addition and was therefore not induced by nitrate. Ethylbenzene utilization was concomitant with that of *m*-xylene. The soil column required 7 days to reach a maximum toluene removal (data not shown). Addition of 0.8 mg/L oxygen to the inlet nitrate stream did not change the removal observed for combined BTEX (Table 10). The absence of a negative effect of oxygen on overall BTEX removal under denitrifying conditions has been observed previously (Hutchins et al, 1992). In this test, a slight decrease in removal was observed for toluene along with a greater decrease in *o*-xylene removal. Ethylbenzene removal increased and, although the mean removal of *m*-xylene remained the same, the outlet concentration of *m*-xylene was lower during operation with trace amounts of oxygen. Nitrate utilization and nitrite production were slightly reduced during microaerophilic operation. Based on stoichiometry of complete mineralization under both electron acceptor conditions, the amount of oxygen added was insufficient to compensate for the decreased denitrification activity. In summary, inclusion of oxygen into the inlet stream produced small changes in the removal of individual compounds but did not affect the overall BTEX removal. This indicates that oxygen incorporated into the sprinkler discharge would probably not hinder bioremediation under denitrifying conditions.

TABLE 10. SUMMARY DATA FOR BTEX AND ELECTRON ACCEPTOR REMOVAL IN COLUMNS PREPARED WITH EGLIN AFB AQUIFER MATERIAL COLLECTED PRIOR TO START OF REMEDIATION

Parameter	Denitrification		
	Inlet (mg/L)	Outlet (mg/L)	Removal (mg/L)
Benzene	4.06 ± 0.14	3.74 ± 0.13	0.30 ± 0.14
Toluene	4.84 ± 0.14	0.03 ± 0.0	4.80 ± 0.15
Ethylbenzene	2.75 ± 0.08	0.07 ± 0.02	2.68 ± 0.08
<i>m</i> -Xylene	4.70 ± 0.13	0.26 ± 0.07	4.42 ± 0.16
<i>o</i> -Xylene	4.79 ± 0.11	3.13 ± 0.16	1.64 ± 0.19
BTEX	21.2 ± 0.6	7.23 ± 0.34	13.8 ± 0.6
Nitrate-N	27.6 ± 1.6	7.41 ± 1.38	20.2 ± 1.6
Nitrite-N	0.12 ± 0.02	1.71 ± 0.42	-1.60 ± 0.41
Oxygen	-	-	-
Parameter	Denitrification/Microaerophilic		
	Inlet (mg/L)	Outlet (mg/L)	Removal (mg/L)
Benzene	3.30 ± 0.23	3.06 ± 0.17	0.22 ± 0.18
Toluene	4.64 ± 0.15	0.06 ± 0.15	4.55 ± 0.16
Ethylbenzene	2.92 ± 0.09	0.05 ± 0.02	2.86 ± 0.10
<i>m</i> -Xylene	4.58 ± 0.18	0.08 ± 0.03	4.47 ± 0.19
<i>o</i> -Xylene	4.67 ± 0.16	3.49 ± 0.16	1.18 ± 0.15
BTEX	20.1 ± 0.7	6.74 ± 0.19	13.3 ± 0.7
Nitrate-N	27.3 ± 0.5	10.8 ± 0.7	16.5 ± 0.6
Nitrite-N	0.23 ± 0.03	0.48 ± 0.07	-0.25 ± 0.08
Oxygen	0.80 ± 0.10	0.02 ± 0.01	0.78 ± 0.10

SECTION III

PILOT TEST DESIGN, CONSTRUCTION, AND OPERATION

A. CONCEPTUAL DESIGN PLAN

The initial site characterization and treatability studies demonstrated that:

- (1) the fuel was distributed 3-7 feet below ground surface,
- (2) the fuel was depleted in benzene and toluene,
- (3) the aquifer was anaerobic,
- (4) there was a large, diverse, and viable microbial population,
- (5) selected alkylbenzenes were degraded under denitrifying conditions,
- (6) surface application would be an effective delivery system,
- (7) recirculation of recharge water would plug the aquifer due to colloidal material, and
- (8) nutrient addition would not be required.

Based on this, a conceptual design plan was prepared and submitted Oct 1993 to AL/EQW-OL for review. The basic elements of the conceptual design plan were as follow:

- (1) there would be two adjacent 100-foot x 100-foot cells as shown on Figure 5, with no "buffer zone" between cells,
- (2) application would be at 12.5 GPM/cell, equivalent to 2.5 inch/day,
- (3) application rate and schedule for each cell would be identical,
- (4) application would be by sprinkler or soaker hose,
- (5) recharge water would be obtained from treated ground water used to supply Eglin AFB and would be unamended with the exception of potassium nitrate being applied to the Nitrate Cell at a concentration of 10 mg/L $\text{NO}_3\text{-N}$, and

- (6) there would be no down-gradient collection and treatment process.

The plan was accepted and construction was begun Feb 94.

B. CONSTRUCTION

The pilot demonstration project consisted of three principal components: (1) landscaping and infrastructure, (2) treatment system, and (3) monitoring system. A schematic of the treatment system is shown in Figure 14, and illustrates the principal components in relation to subsurface contamination based on a cross-sectional view.

1. Landscaping and Infrastructure

A 20,000-foot² area was designated for treatment (Figure 15), based on the distribution of residual hydrocarbons. This did not encompass the source area (see Figure 5), because the much higher hydrocarbon concentrations found here would have necessitated an additional side-by-side treatment comparison on this smaller area in addition to the larger area, and this was not practical. Two 100-foot x 100-foot treatment cells were delineated for treatment, with the southwest cell being designated as the Nitrate Cell and the northeast cell being the Control Cell (Figure 15). The land surface of the cells was generally covered with bermuda grass, although vegetation was more sparse adjacent to the source area. There was also a large pine tree at the western edge of the Control Cell. The surface soil was sandy, except in the southwestern corner of the Control Cell, where the surface soil consisted of red loam/clay fill which had been brought in previously to provide a bed for the above-ground storage tanks.

Plastic sheeting was installed in a trench separating the two treatment cells to minimize crossover during infiltration to the water table. The depth ranged from 2.0-2.5 feet (at the water table) on the east side to 4.0-4.5 feet (above the water table) on the west side. A soil berm was then built over the filled trench to prevent runoff onto the Nitrate Cell, since the land surface sloped down towards the southeast (see Figure 1). Other than this, there was no surface or subsurface construction for hydraulic containment. During trenching for the plastic sheet, we observed that the red loam/clay fill extended about a foot down on the west side and then decreased eastward until it disappeared, about 2/5 of the way across the Control Cell. This fill material did not extend appreciably into Nitrate Cell. Because ponding had been observed on this material during rainfall, trenches were installed over part of the Control Cell to facilitate infiltration (Figure 15). These trenches were cut in an irregular pattern (to avoid subsurface PVC and electrical lines) and backfilled with clean sand from other locations. Fill soil, which had been cleaned by roasting, was used to overlay the sand. Finally, the entire area was reseeded with grass and fertilized, both within and outside of treatment cells, by Base personnel.

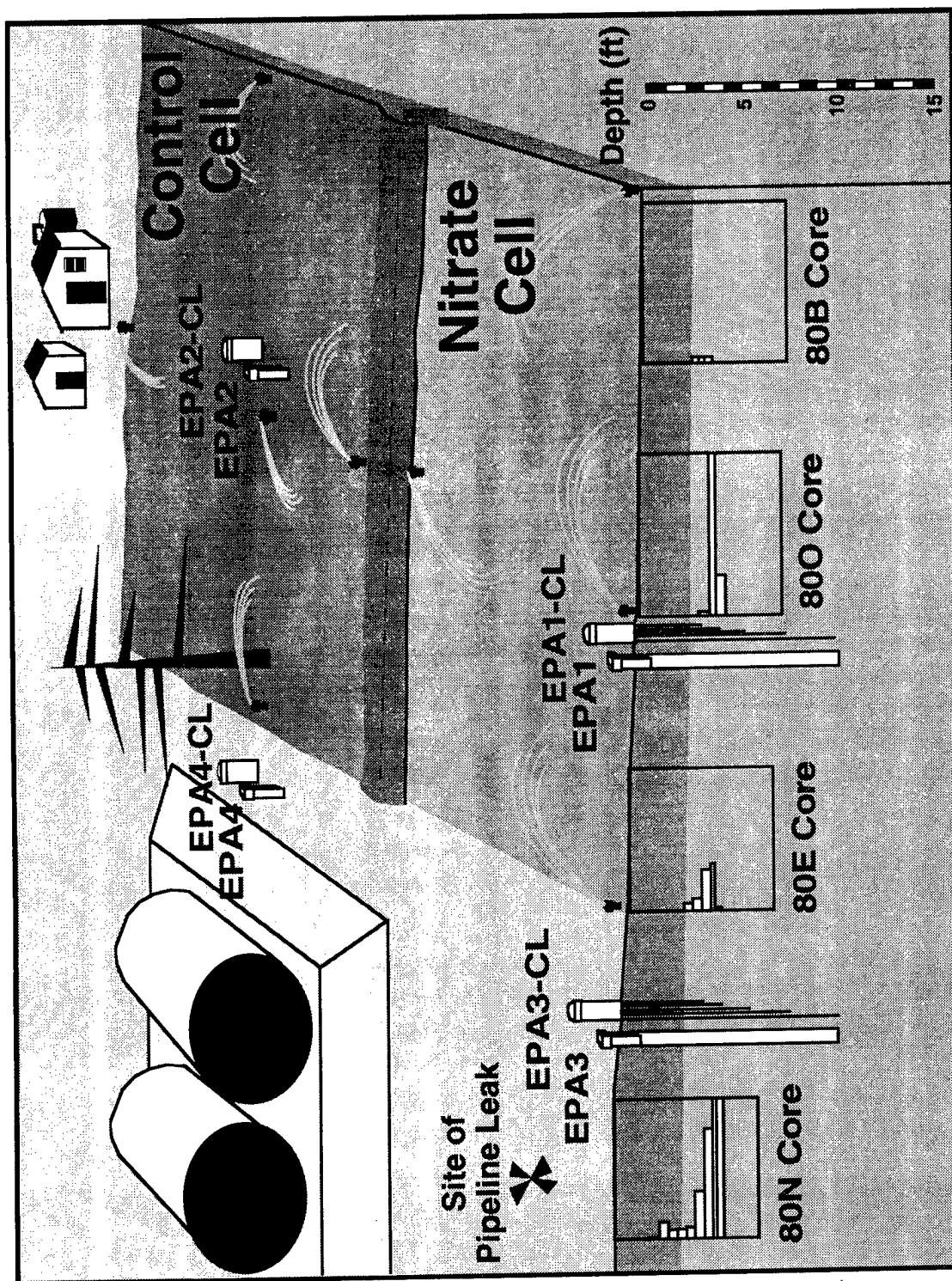


Figure 14. Schematic of Pilot Demonstration Project, Showing Locations of Treatment Cells in Relation to EPA Wells and JP-4 Contamination in Selected Cores.

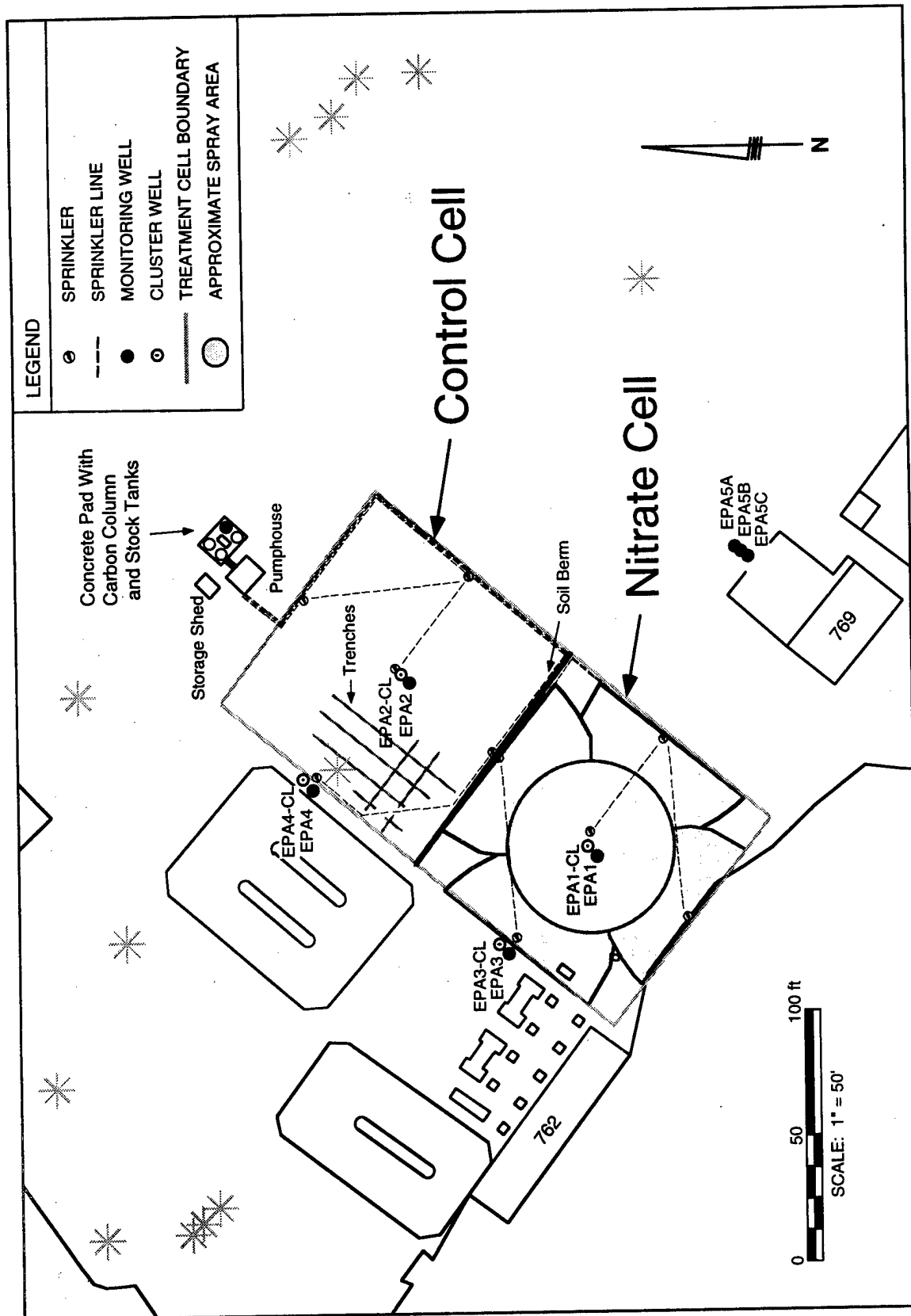


Figure 15. Construction Details of Pilot Demonstration Project, Showing Locations of Pumphouse, Sprinklers, Trenches, and Cluster Wells. The Approximate Spray Area is Shown for the Nitrate Cell Sprinklers.

2. Treatment System

The treatment system consisted of a series of outdoor storage tanks, a pumphouse for mixing and delivery of the treated water, and a sprinkler distribution system. The recharge water was obtained from the Floridan Aquifer, the same source that provided ground water for that part of the Base. The water was essentially clean, with approximately 15 mg/L sodium, 3 mg/L potassium, 25 mg/L calcium, 15 mg/L magnesium, and less than 0.05 mg/L iron and manganese. The pH was 7.6 and there was no measurable dissolved oxygen. The recharge water contained approximately 7 mg/L chloride, 9 mg/L sulfate, 0.1 mg/L $\text{NO}_3\text{-N}$, 0.3 mg/L TOC, and less than 0.5 mg/L bromide and less than 0.05 mg/L each of $\text{NO}_2\text{-N}$, $\text{NH}_4\text{-N}$, and $\text{PO}_4\text{-P}$. BTEXTMB and JP-4 were not detected. Because the water had been chlorinated and still contained 1.8 mg/L chlorine as residual, it was routed through a carbon column to remove chlorine prior to being used as recharge. The carbon column was located outside on a concrete pad, along with three 500-gallon storage tanks and one 300-gallon storage tank. One of the storage tanks was used as a nitrate stock tank, and contained technical grade (99%) potassium nitrate (Van Waters & Rogers, Mobile, AL) at a design concentration of 4000-5000 mg/L $\text{NO}_3\text{-N}$. This was periodically amended with sodium bromide (Van Waters & Rogers, Mobile, AL) at a design concentration of 25000 mg/L Br when tracer studies were performed. The 300-gallon stock tank was used as the stock tank for the Control Cell when tracer studies were underway, and contained sodium chloride (Sam's Warehouse, Shalimar, FL) at a design concentration of 40000 mg/L Cl. The remaining two 500-gallon tanks were designated as mixing tanks. Mixing for each tank (except the chloride stock tank) was accomplished by recirculating water with the indoor pumps. In addition, each tank was equipped with two float-valve solenoids for measuring high and low water levels.

The treatment system was designed so that, once water levels dropped to the low water-level limit in either of the mixing tanks, water from the carbon column and the appropriate stock tank was routed into both mixing tanks at a fill rate which exceeded the discharge rate. Similarly, when either of the high water-level limits was attained, the fill for both tanks was discontinued. This permitted continuous operation. Water flow and system operation were checked daily, and totalizers were used to measure the cumulative volumes being delivered to each treatment cell. Recharge water was pumped to both cells through PVC pipe into a conventional sprinkler distribution system (Figure 15). Each cell contained nine adjustable sprinkler heads (Rainbird), of which only five were used during this study. For each cell, the single center sprinkler head was set to rotate 360 degrees and the side sprinkler heads were set to rotate 180 degrees so that water was applied to the interior of the cells. The sprinkler system was designed to have overlapping spray areas, thereby providing adequate and even water distribution across most of the cell, except perhaps for the four corners. Although sprinkler heads had also been installed in the corners of each cell, and the system was designed to switch sprinkler patterns over a 24-hour cycle,

this led to too many problems in balancing the flows between the mixing tanks. Flow imbalances typically accumulated over a short time interval, causing one mixing tank to trip the low water-level sensor while the other tripped the high water-level sensor, causing shut-down. To avoid this, we decided not to use the corner sprinkler heads. This arrangement resulted in an average net flow of 11.0-11.5 GPM/cell.

3. Monitoring System

Application water and ground water quality were monitored continuously during system operation using both conventional and cluster monitoring wells. For each cell, a fully-penetrating well and a cluster well were placed in the center and at one of the edges (Figure 14). The Nitrate Cell contained EPA1 and EPA3, at the center and at the edge, respectively, while the Control Cell contained EPA2 and EPA4 at its corresponding center and edge. The fully-penetrating wells were constructed of 2-inch PVC and screened 1-11 feet below ground surface, as described in Table 1. The cluster wells consisted of five individual wells per cluster and were installed separately, adjacent to the fully-penetrating wells, using a geoprobe (Figure 15). Each cluster well was constructed of 1/4-inch polypropylene tubing with a 2.5-inch 80-mesh steel screen. The top of each cluster well was sealed with a Teflon® plug valve. The wells were installed 4.0, 5.0, 6.5, 8.5, and 11 feet below ground surface for each cluster location (Figure 16). This was done to provide depth-discrete information on water quality as recharge infiltrated through the vadose zone and migrated downward through the saturated zone in each of the cells. A larger, less discrete cluster was designated EPA5 and installed downgradient of the Nitrate Cell (Figure 15). This consisted of three 2-inch PVC wells, screened at 1-11 feet, 11-21 feet, and 21-31 feet for EPA5A, EPA5B, and EPA5C, respectively. This well cluster was installed primarily to determine whether nitrate was escaping from the system or being utilized within the treatment cells.

For sampling the 2-inch wells, a Grundfos submersible pump was used. The pump was set sequentially at the top, bottom, and middle of the water column and pumped for 5 minutes at 3 L/minute for each level to purge each well. This resulted in the clearance of approximately ten well volumes from EPA1-5A, five well volumes from EPA5B, and three well volumes from EPA5C. Although the total purged well volumes were different for the EPA5 cluster, the amount of water pumped through the well screens was approximately the same. The flow rate was then reduced to approximately 0.5 L/minute and samples were obtained from the middle of the water column. Dedicated polyethylene lines were used for each 2-inch well. For sampling the small cluster wells, a peristaltic pump with multiple heads was connected directly to the wells. The wells were purged for 5 minutes at 100 mL/minute (>10 well volumes) and sampled at the same rate. Once sampling was complete, the plug valves were closed, trapping the water column and not allowing air to re-enter the well lines.

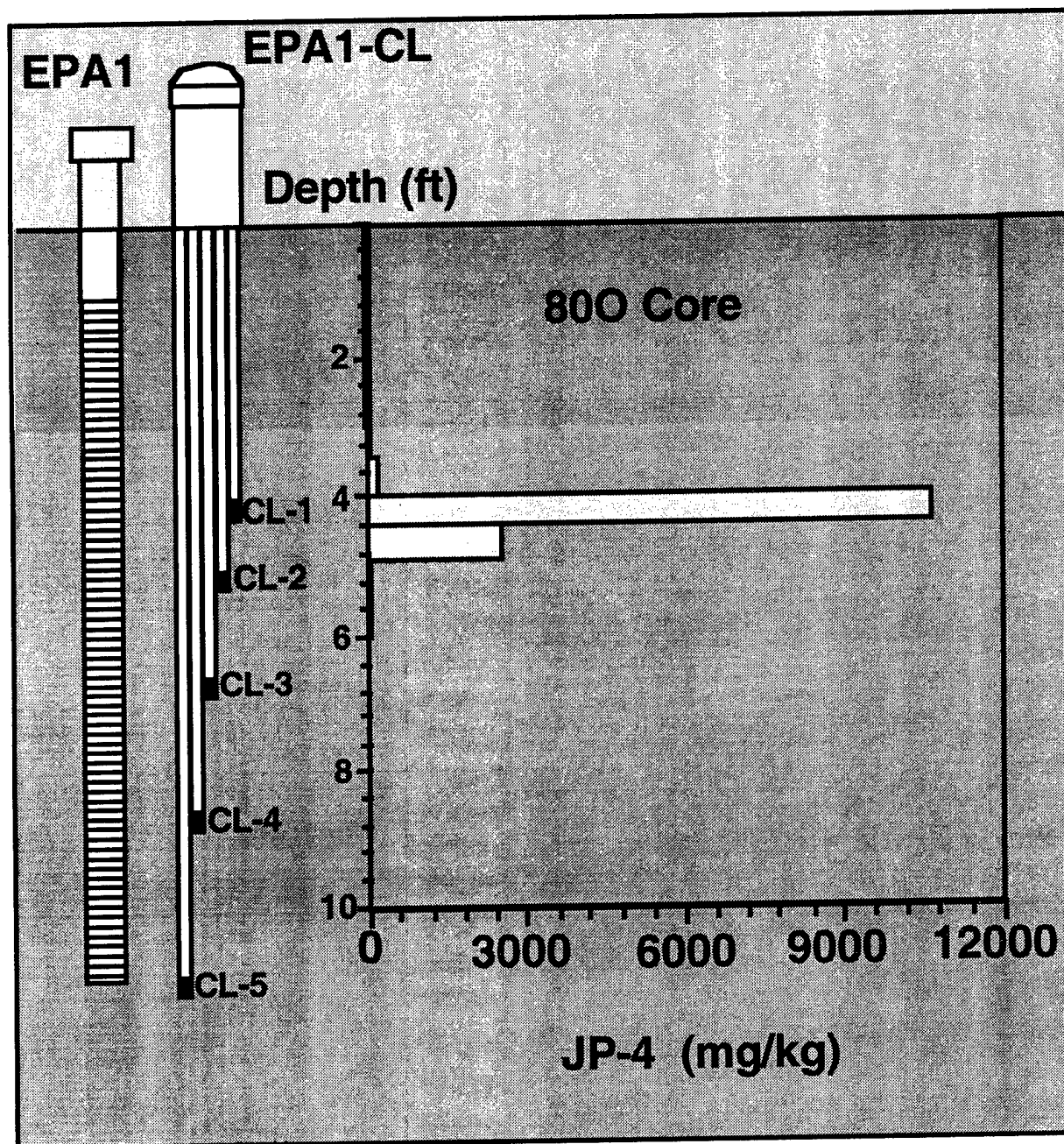


Figure 16. Construction Details of EPA1 Cluster Well, Showing Locations of Well Screens in Relation to EPA1 and JP-4 Contamination in 800 Core.

C. OPERATION

1. Operational Summary

The complete operating history, showing operating events, total flows, shut-down intervals, water-level measurements, and rainfall data is provided in Appendix B. The most important of these operating events will be discussed more fully in later sections of this report, but are summarized as follows:

- (1) operation began Apr 7, 1994, with separate tracers being added to the sprinkler recharge waters for each of the two treatment cells during the first 2-week interval,
- (2) a second tracer study was conducted Jun 10-18, 1994,
- (3) nitrate levels were increased to 15-20 mg/L NO₃-N on July 15, 1994,
- (4) an Interim Performance Evaluation was conducted Aug 19-30, 1994,
- (5) a 30-foot x 30-foot plot inside each cell was stripped of vegetative cover and covered with weed barrier to enhance nitrate transfer into the subsurface on Nov 14-16, 1994,
- (6) the pilot project was discontinued and the Final Performance Evaluation was conducted May 13-30, 1995, and
- (7) a final round of water samples were collected Apr 19-21, 1996.

The schedule of operating events, relative to the amounts of water and nitrate added to the respective cells, is shown in Table 11.

2. Monitoring Schedule

Monitoring consisted of daily operational checks, periodic measurements of water levels in area wells, periodic water quality analyses from EPA wells, and two Performance Evaluations involving both extensive core and water analyses. For daily operational checks, the following parameters were measured for each cell: (1) sprinkler status, (2) totalizer volumes, (3) sprinkler water pressure, (4) fill flow rate, (5) stock flow rate, (6) cell flow rate, (7) mix tank level, and (8) stock tank level. In addition, both rainfall and weather conditions were recorded. Water level measurements were made on monitoring wells located both within and next to the two treatment cells to observe build-up of the water table mound during start-up operations and to monitor water table response to rainfall events. These wells included EPA1, EPA3, Well I1, and Well R4 in the Nitrate Cell, EPA2, EPA4, Well I2, and Well D in the Control Cell, and

TABLE 11. TIMELINES AND MASS LOADINGS FOR OPERATION OF PILOT DEMONSTRATION PROJECT ON NITRATE-BASED BIOREMEDIATION

Event	Parameter*	Nitrate Cell	Control Cell
Start-Up (Apr 7, 1994)	Elapsed Time (d)	0	0
	Recharge (ft)	0	0
	NO ₃ -N (kg)	0	0
Increase NO ₃ -N (Jul 15, 1994)	Elapsed Time (d)	95	95
	Recharge (ft)	19.9	20.6
	NO ₃ -N (kg)	57	0
Interim Performance Evaluation (Aug 19-30, 1994)	Elapsed Time (d)	126	126
	Recharge (ft)	26.5	27.4
	NO ₃ -N (kg)	94	0
Sod Removal and Stripped Plot Construction (Nov 14-16, 1994)	Elapsed Time (d)	197	197
	Recharge (ft)	41.9	43
	NO ₃ -N (kg)	176	0
Final Performance Evaluation (May 13-30, 1995)	Elapsed Time (d)	368	368
	Recharge (ft)	79.0	80.2
	NO ₃ -N (kg)	394	0

* Elapsed time corrected for days the system was down.

EPA5, Well R2, Well R3, Well R4, and Well C downgradient of both treatment cells. These measurements were made daily for the first 2 weeks of operation and then weekly afterwards. Data for the daily operational checks and the water level measurements are in Appendix B. The seven fully-penetrating EPA wells (EPA1-4, EPA5A-5C) and the four EPA cluster sets were routinely monitored during pilot operation. Monitoring was done once every 3 to 4 days for the first 3 weeks, and then once every 2 weeks afterwards. Monitoring was done more frequently for the EPA cluster wells when tracer tests were being conducted. Water samples were either analyzed in the field or shipped back at RSKERL for analysis as described previously (Section IIB2). This resulted in an extensive dataset collected over a full year of operation (Appendix C). In addition, water samples were obtained periodically for additional analyses, such as dissolved gases or organic acid and phenolic intermediates of biodegradation. These are described more fully in the respective sections on the Performance Evaluations, which also include the acquisition of core samples for monitoring the progress of bioremediation.

SECTION IV

PERFORMANCE EVALUATION

A. WATER LEVEL RESPONSE

Rainfall data and monitoring well data were used to characterize the water table response to sprinkler application and rainfall events. These data have been tabulated in Appendix B. In general, the pattern of response was the same for all wells, as shown by the example data for the EPA wells at the centers and the edges of the treatment cell (Figure 17). The water table is very responsive to rainfall, and in fact the water table was at ground surface in the nitrate cell on July 4 following several heavy rainfall events (Figure 17). This frequent rainfall makes it difficult to gauge the extent of the water table mound created by operation of the pilot system. The initial water table rise at the start of the project was approximately 0.8 feet, but there were too few data taken previous to this event to determine whether regional levels had been rising or falling. During the two sampling intervals in which the operation was shut down for long periods of time, the water level in EPA1 dropped 1.2 feet in 12 days during the Interim Performance Evaluation and then 2.4 feet in 15 days during the Final Performance Evaluation (Figure 17). Assuming an average value of 1.5 feet for the water table mound, this is only 60% of the predicted mound of 2.5 feet (Section IIB5). The most likely reason for this discrepancy is that the effective aquifer thickness was underestimated. The effective thickness of the aquifer, that thickness which is affected by the surface application, is difficult to estimate. The initial predictive runs using BIOPLUME assumed an effective thickness of 5 feet. However, an effective thickness of 8 feet, with all other parameters remaining the same, yields the observed water table mound of 1.5 feet. Based on the tracer data, as discussed in the next section, the effective thickness was at least 8.5 feet. The water table mound was contoured based on area wells both before and during operation, and illustrates that the regional ground water gradient is overcome in the vicinity of the treatment cells (Figure 18).

B. WATER QUALITY ANALYSES

1. Tracer Studies

Tracer studies were conducted at two different times: (1) at the start of operation, to evaluate water movement when the vadose zone was initially low in water content, and (2) during operation, to evaluate water movement under saturated operating conditions. Two different tracers, bromide for the Nitrate Cell and chloride for the Control Cell, were used to differentiate between the Nitrate Cell recharge and the Control Cell recharge. There was no significant migration of tracer (ie, above background levels) from one cell to the next (Appendix C). In both tests, however,

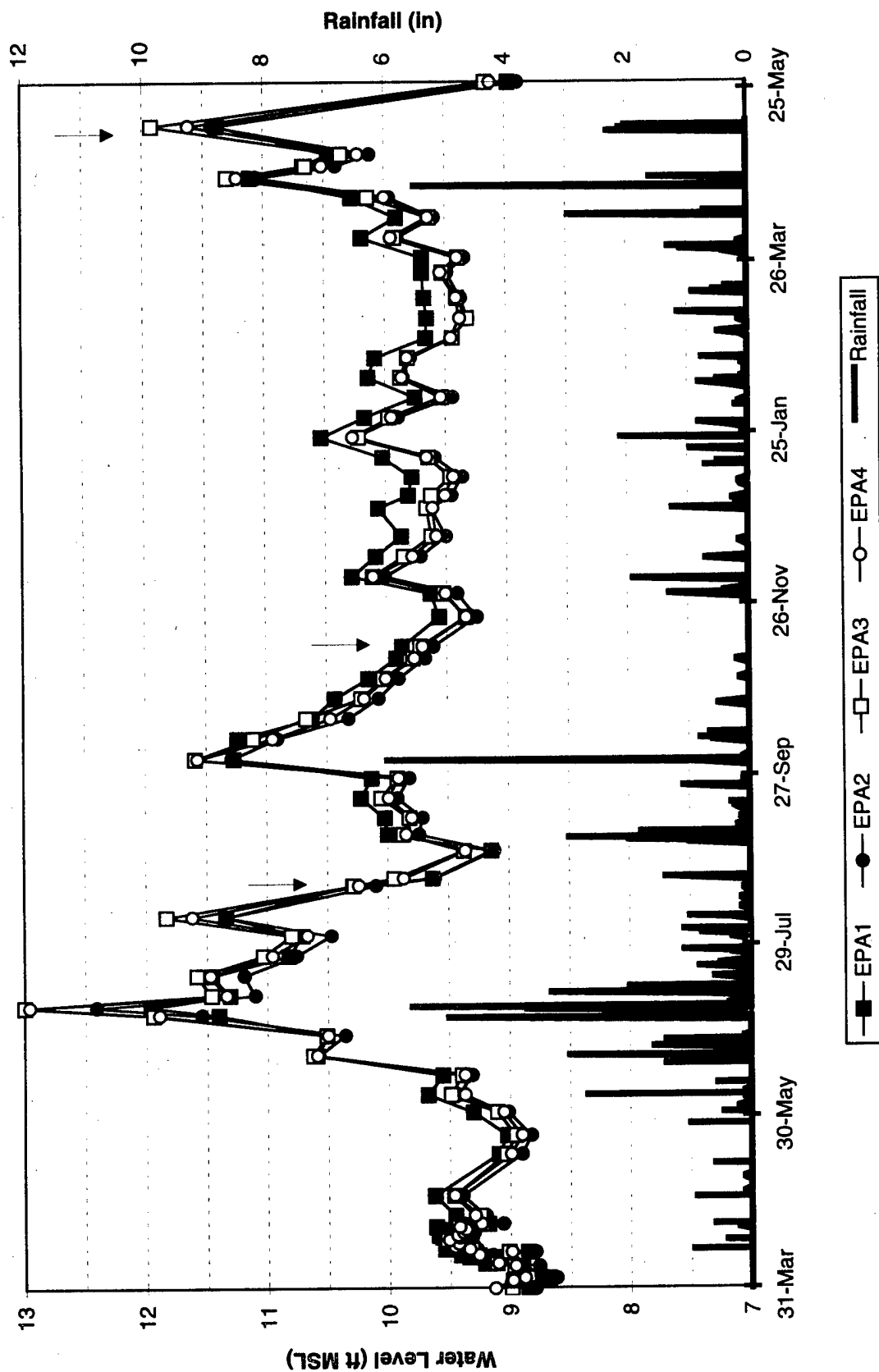


Figure 17. Water Level Response to Sprinkler Application and Rainfall Events in Pilot Demonstration Wells.
Arrows Denote Times Sprinklers were Turned Off for Sampling Events.

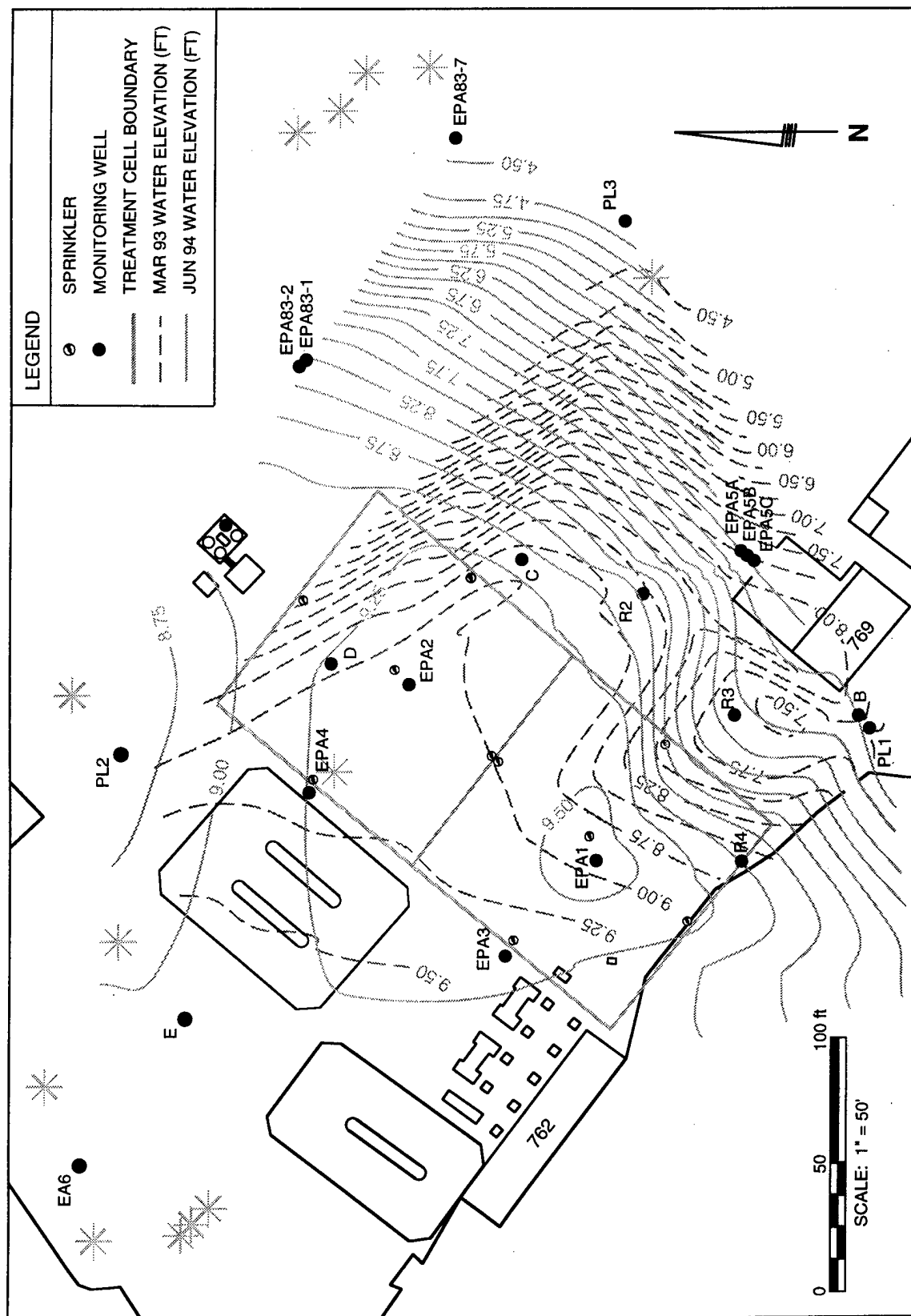


Figure 18. Water Elevation Contours Prior to (Mar 93) and During (Jun 94) Operation of the Pilot Project.

problems were encountered in maintaining steady influent tracer concentrations. This was because mixing of the nitrate and bromide salts in the stock tanks was incomplete, resulting in gradient separation. This incomplete mixing yielded influent tracer concentrations that were initially higher than the expected values, and then decreased and stabilized with time. This problem was not observed as much during the first tracer test, probably because adequate time was available for mixing due to several delays encountered in starting up the operation. In addition, heavy rainfall occurred at the end of the second tracer study, which could have affected travel times. In fact, EPA4-CL1, typically dry, began to yield water because of the rising water table. Due to these problems, estimates of breakthrough time are probably less relevant than observations of the depth of tracer migration and the sequential order of tracer appearance in the cluster wells.

For each cluster well, three graphs are presented: (1) overall tracer data for the entire duration of the pilot test, normalized to the highest concentration, (2) tracer data for the first month of operation, and (3) tracer data for the third month of operation. The latter two graphs are scaled up to better visualize the order of tracer breakthrough. Tracer data for the EPA1 Cluster Wells, located in the center of the Nitrate Cell, are shown in Figure 19. During wetting, breakthrough of bromide followed in sequence with depth, except for the lower two levels (Figure 19b). After the vadose zone was saturated, however, site heterogeneities began to become apparent, since the breakthrough order in the second tracer test was CL2 > CL4,5 > CL3,1 (Figure 19c). In particular, CL1 is somewhat isolated from the flow path, at least relative to the increased mass flux moving through the other levels. The hydraulic residence time is difficult to estimate from these data, but is on the order of 10 to 15 days for most of the levels. (Figure 19c). There did not appear to be any influence of the initial tracer test on the second tracer test. Tracer data for the EPA3 Cluster Wells, located at the edge of the Nitrate Cell, are shown in Figure 20. In the first tracer study, tracer flow is limited to the upper two levels, with CL1 breaking through before CL2 (Figure 20b). CL3 and CL5 began to show breakthrough long after influent concentrations were reduced, and in fact peaked during the second tracer test (Figure 20c). In contrast, CL4 only begins to show breakthrough during the second tracer test; this indicates that there are substantial differences in horizontal conductivity as well, since CL4 and CL5 broke through at roughly the same time in the center of the cell (Figure 19b). As with the initial test during the wetting phase, the only breakthrough evident in real time during the second test at the EPA3 cluster was at the upper two levels, in sequential order (Figure 20c). The amount of applied water which reached the deeper cluster wells at the edge of the cells is difficult to quantify, because we don't know at which depth the regional flow overcomes the mound effects at these locations. However, the chloride data obtained over the entire pilot demonstration period indicate that these deeper zones received substantial amounts of recharge (Appendix C). Initially, chloride levels were generally low (3-5 mg/L) for all cluster wells at this location, but gradually rose to recharge levels (8-10 mg/L) during the study, indicating that most of the aquifer had been cleared of the native ground water. These tracer data show that all of the edge

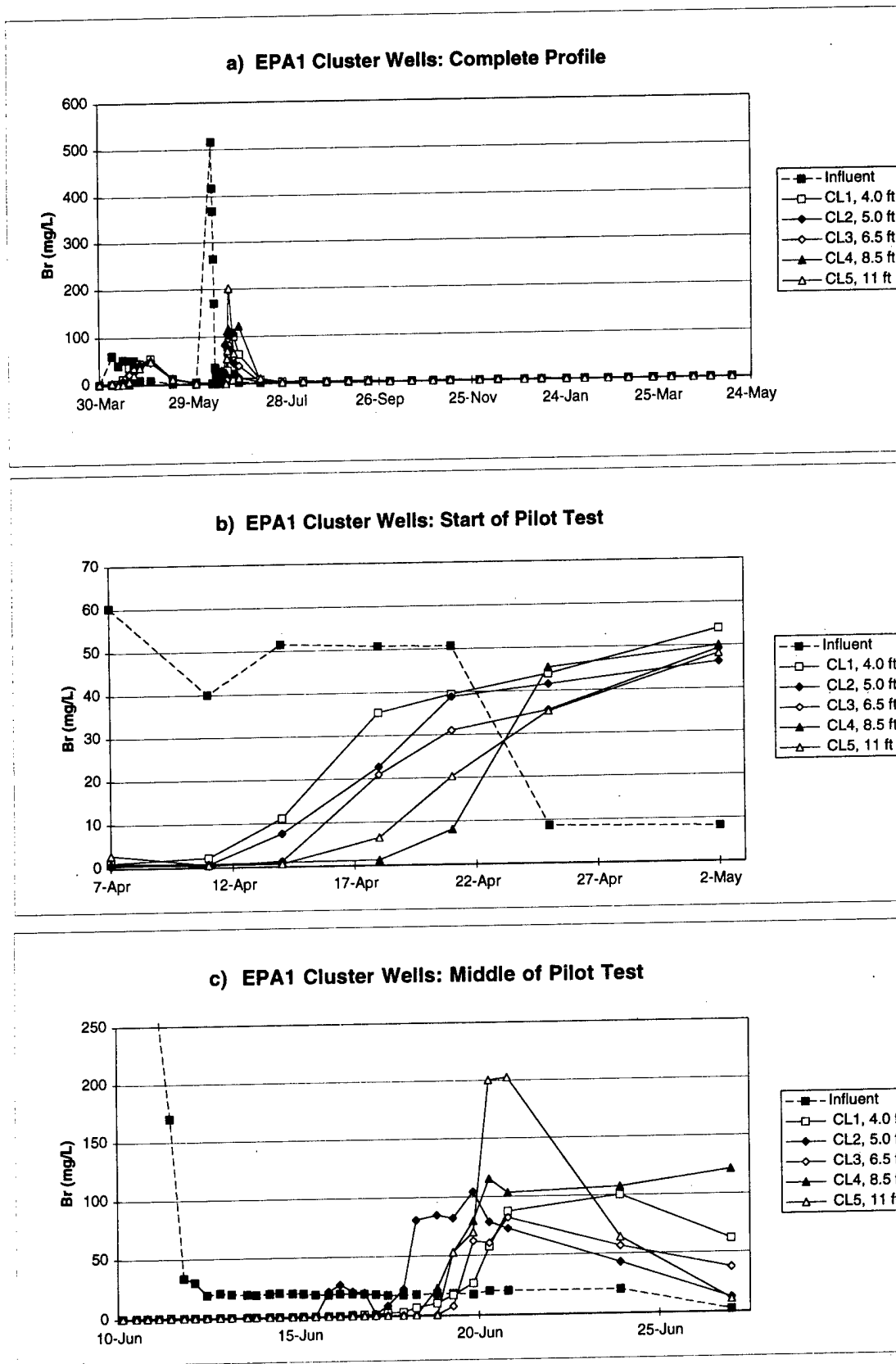


Figure 19. Breakthrough of Bromide in EPA1 Cluster, Center of Nitrate Treatment Cell, Showing: a) Complete Profile, b) Profile at Start of Test, and c) Profile at Middle of Test

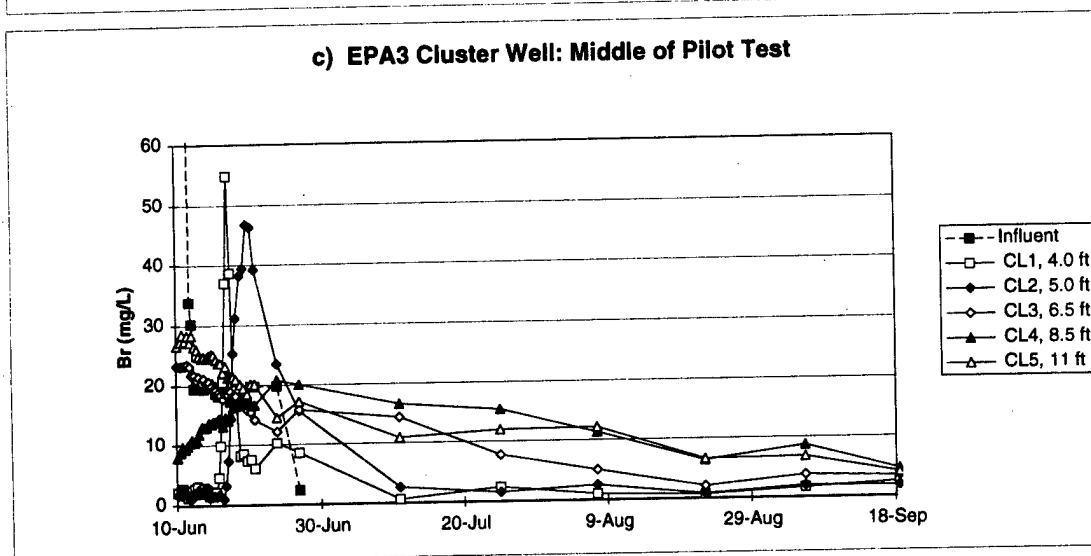
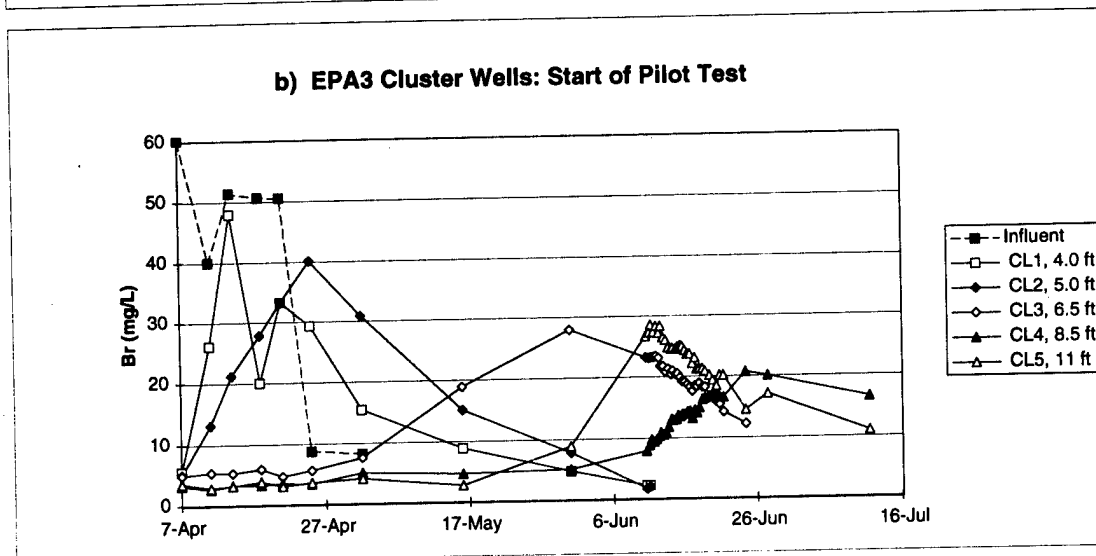
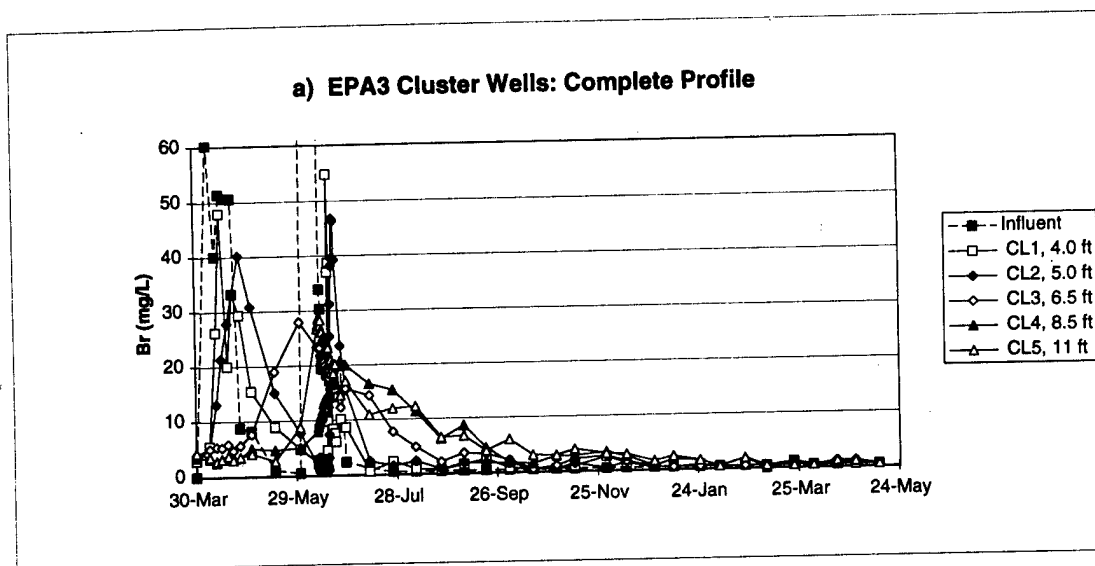


Figure 20. Breakthrough of Bromide in EPA3 Cluster, Edge of Nitrate Treatment Cell, Showing: a) Complete Profile, b) Profile at Start of Test, and c) Profile at Middle of Test

cluster wells were therefore influenced by the applied water, although the deeper wells were probably less affected because of the increased travel time.

Tracer data for the EPA2 Cluster Wells, located in the center of the Control Cell, are shown in Figure 21. In contrast to the Nitrate Cell, breakthrough was much more evenly correlated with depth during the wetting phase (Figure 21b). Perhaps this is due to the ground surface being about a foot higher than the water table at this location, giving more vadose zone initially. Even during the second test, however, breakthrough followed in sequential order (Figure 21c). Compared to the Nitrate Cell, breakthrough occurred much more rapidly at CL1, about the same at CL2, and much slower at the lower levels. The degree of vertical heterogeneity was therefore much less in the Control Cell. This could be due to a number of reasons, including a lesser number of gravel trenches, plastic barriers, and abandoned wells remaining in this area from the hydrogen peroxide study (Figure 2). Tracer data for the EPA4 Cluster Wells, located at the edge of the Control Cell, are shown in Figure 22. Breakthrough for the first tracer study was again in sequential order (Figure 22b). At first, it may seem surprising that breakthrough occurs at the lower three levels during the wetting phase, since this was not observed at the edge of the Nitrate Cell, and breakthrough at the lower levels in the center of the Control Cell occurred later relative to those in the Nitrate Cell. However, this was probably due to two reasons: (1) the area around EPA4 Cluster contains 0.6 to 1.0 feet of red clay fill, which might have forced a stronger vertical gradient inward from the edge of the cell, and (2) horizontal trenches had been dug and backfilled with more permeable soils and sands, which would have accelerated this localized downward migration. A similar result was seen during the second tracer study (Figure 22c). Although it appeared as if tracer broke through at CL1 after CL2, this was probably an artifact caused by CL1 being dry until almost the end of the study. In summary, these tracer studies demonstrated that recharge could penetrate to below 11 feet at the edges of the treatment cells as well as at the centers, and therefore provided adequate transport of recharge water throughout the contaminated intervals.

The EPA5 cluster was used to monitor whether nitrate was not being utilized and was being transported to the bulk ground water. These wells were therefore analyzed for both tracers to better define migration of the recharge water. Figure 23 shows bromide and chloride concentrations downgradient of the treatment cells in the EPA5 cluster set. This cluster was indeed affected by operation of the Nitrate Cell, as shown by a gradual response to the bromide tracer studies at each level (Figure 23a). It is of interest to note that bromide breakthrough occurred in approximately the same manner for the two lower levels, indicating that the applied recharge was probably penetrating to well below 11 feet in the Nitrate Cell. It is difficult to say whether the tracer profiles for the EPA5 cluster wells result from the first, second, or combination of both sets of tracer studies. There appears to be a double spike at EPA5A, the highest level, but the data are too few to resolve this clearly. In any event, the apparent hydraulic residence time is on the order of 6 to 8 months for each of the levels (Figure

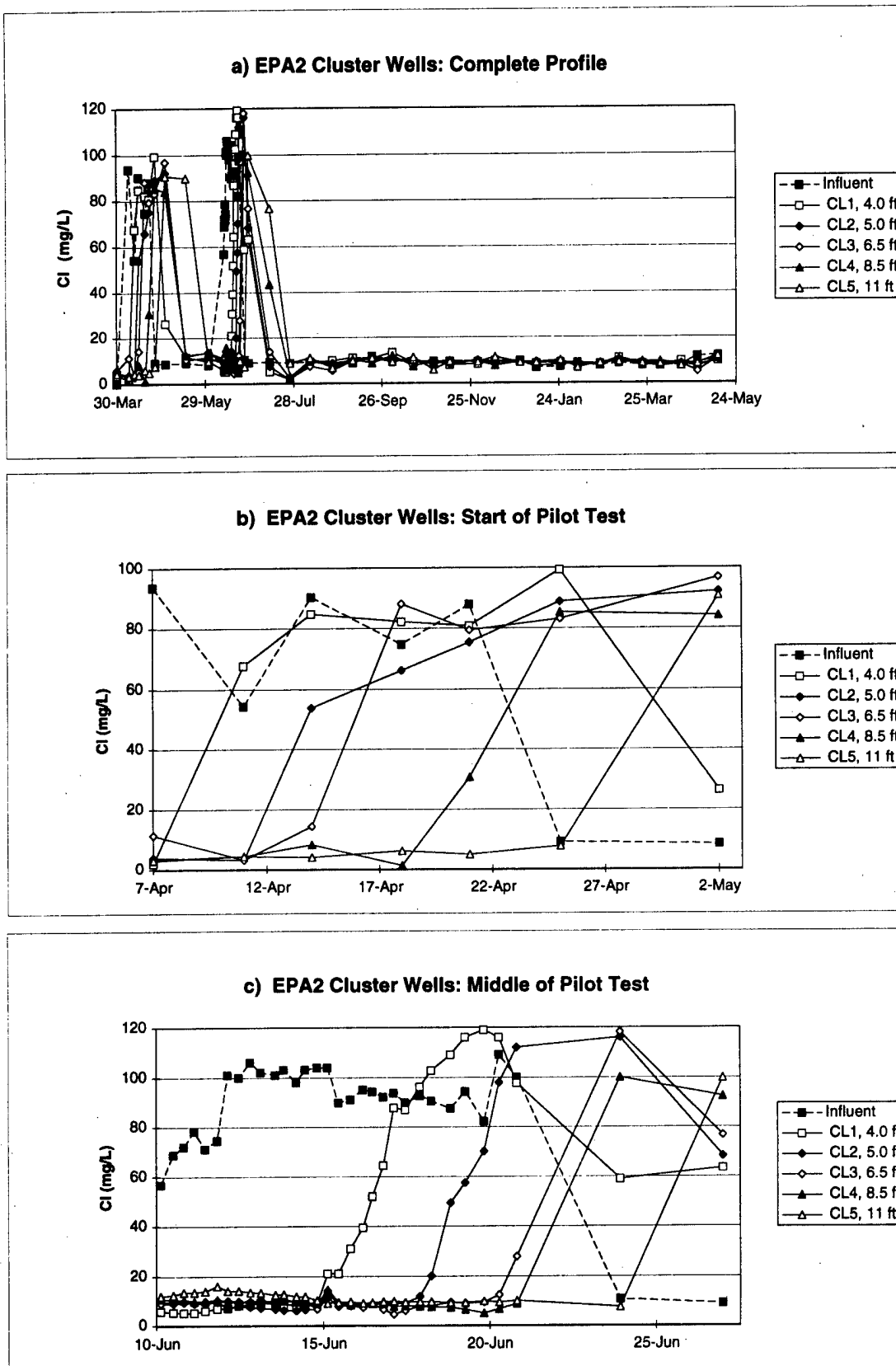


Figure 21. Breakthrough of Chloride in EPA2 Cluster, Center of Control Treatment Cell, Showing: a) Complete Profile, b) Profile at Start of Test, and c) Profile at Middle of Test

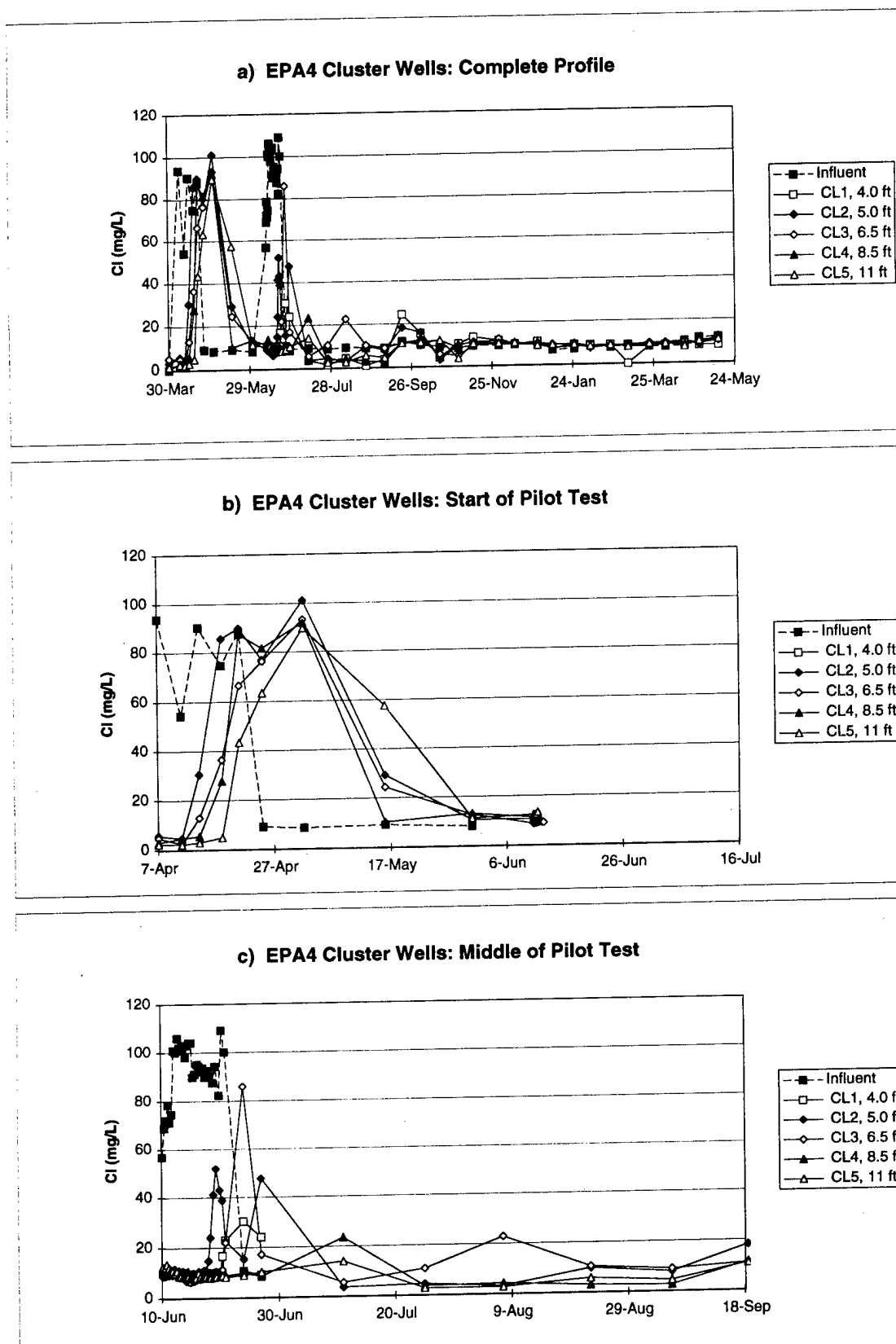


Figure 22. Breakthrough of Chloride in EPA4 Cluster, Edge of Control Treatment Cell, Showing: a) Complete Profile, b) Profile at Start of Test, and c) Profile at Middle of Test

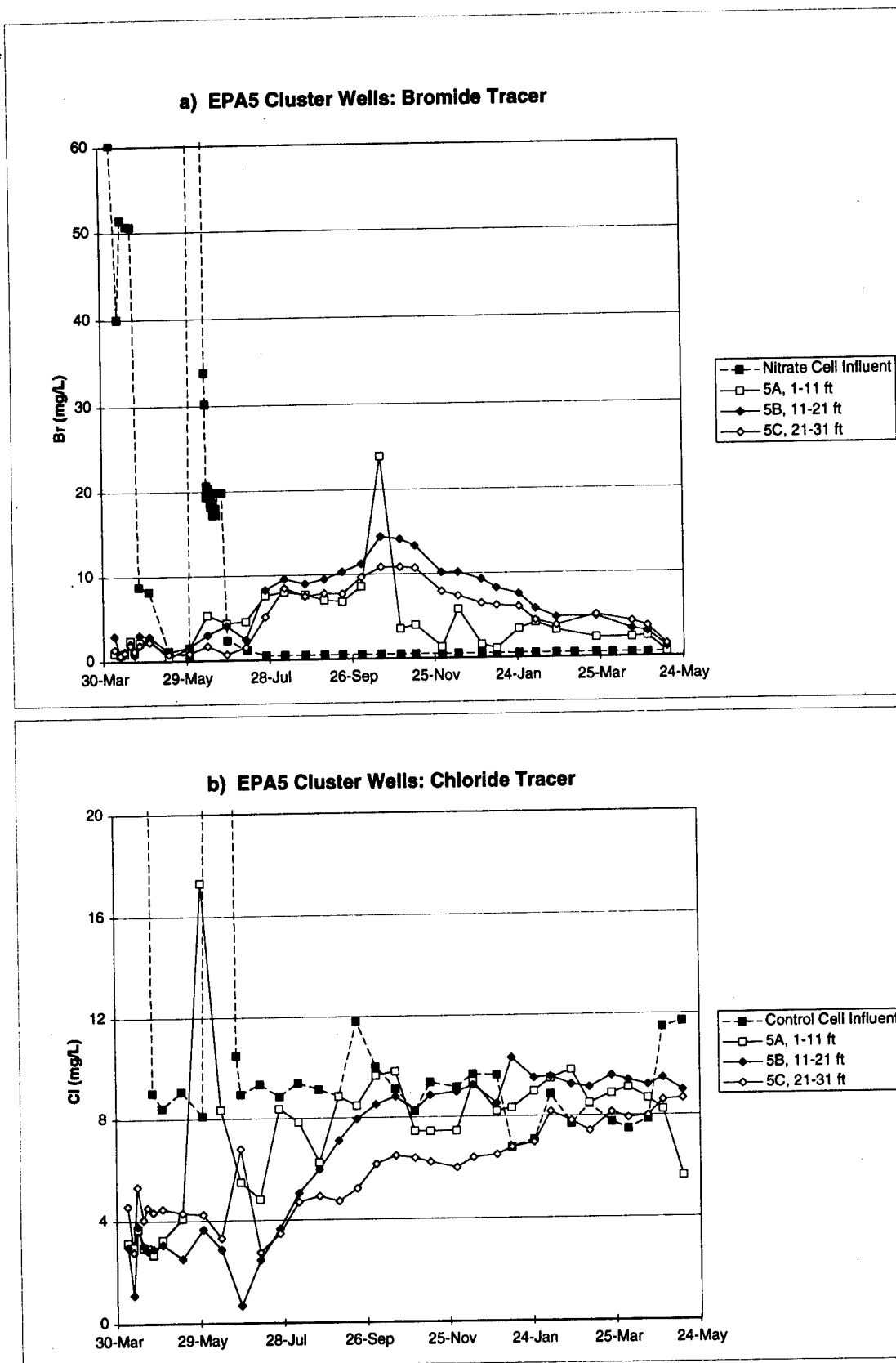


Figure 23. Breakthrough of a) Bromide and b) Chloride Tracers in EPA5 Cluster, Downgradient of Nitrate Treatment Cell

23a). The chloride data are more difficult to interpret (Figure 23b). This is because chloride, unlike bromide, is present naturally at the site, and can be leached from the soil, especially during sustained infiltration as occurred at the beginning of the study. This may be the cause of the chloride spike observed in EPA5A early in the study on May 29 (Figure 23b). Chloride concentrations increased in each of the EPA5 wells, although more gradually than bromide concentrations (Figure 23a, b). This increase was probably not due to the chloride tracer used in the Control Cell, but rather due to the background chloride present in the recharge water, which is about twice that initially present in the ground water at EPA5. This natural tracer gives a better assessment of the effect of treatment cell operation on ground water quality at this location, and shows that it took approximately 5, 7, and 14 months for recharge to replace the water in EPA5A, EPA5B, and EPA5C, respectively.

2. Monitoring Well Data

The complete monitoring well dataset for the EPA Project Wells has been archived as Appendix C. Because of the large amount of data available, it would not be beneficial to provide a thorough evaluation of all of the data within this report. In addition, reference will often be made to Appendix C rather than specific graphs, to limit the number of graphs and tables in this report. The following discussion focuses primarily on those data that contribute to the understanding of the microbial processes occurring in the subsurface.

a. Conventional Wells vs Cluster Wells

Monitoring well data were obtained from conventional, 2-inch PVC wells as well as 1/4-inch cluster wells. It soon became apparent that different results were obtained for the two types of wells, even after corrections were made for locations of screened intervals. For example, EPA1 was screened from 1-11 feet below ground surface, whereas the adjacent EPA1 Cluster had well points at approximately 4.0, 5.0, 6.5, 8.5, and 11 feet below ground surface. To provide a rough comparison to the conventional well, data from each of the five well points were simply averaged. This gave a reasonable match in conservative water quality indices, as illustrated by the tracer data for the four locations during each of the two tracer studies (Figure 24). In contrast, nonconservative parameters such as BTEXTMB, nitrate, and dissolved oxygen, were often quite different (Figure 25). For example, the conventional well in the Nitrate Cell showed a rapid loss of BTEXTMB and a gradual breakthrough of nitrate and, to a lesser extent, oxygen (Figure 25a). However, the cluster wells indicated that the ground water still had high concentrations of BTEXTMB, and nitrate and oxygen levels were much lower (Figure 25b). Similar discrepancies in the results, although to a lesser scale, were obtained for the well pairs in the center of the Control Cell (Figure 25c,d). One explanation for this discrepancy is that the conventional monitoring wells do not provide a true representation of the aquifer environment under these operating conditions. It is possible that the infiltrating recharge enters into the

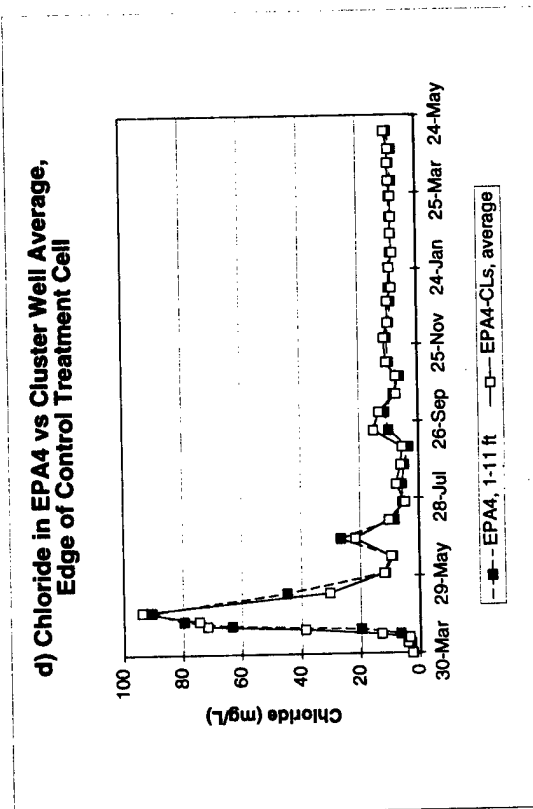
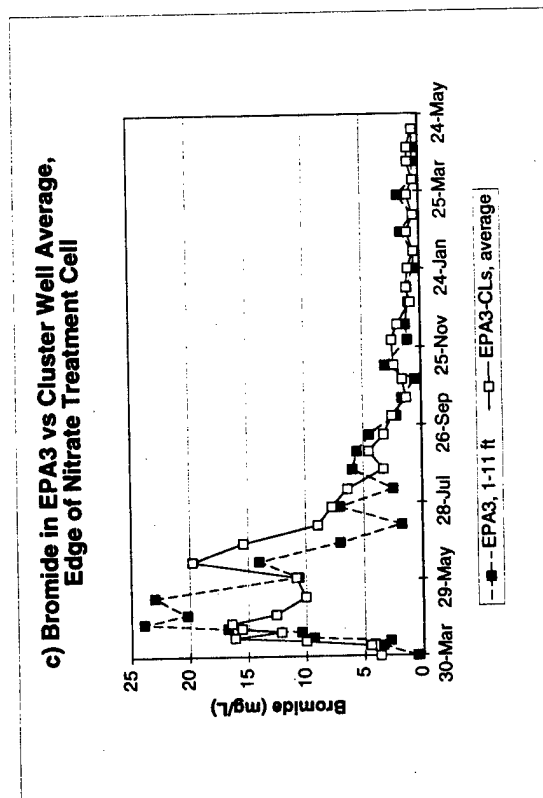
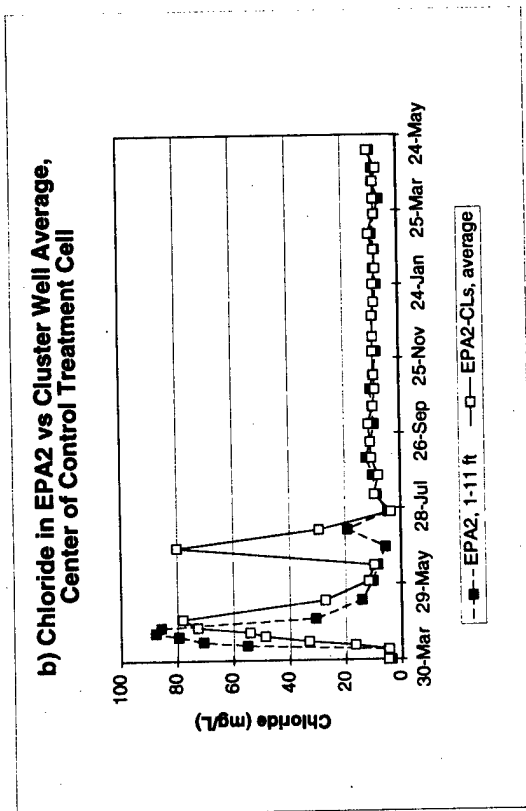
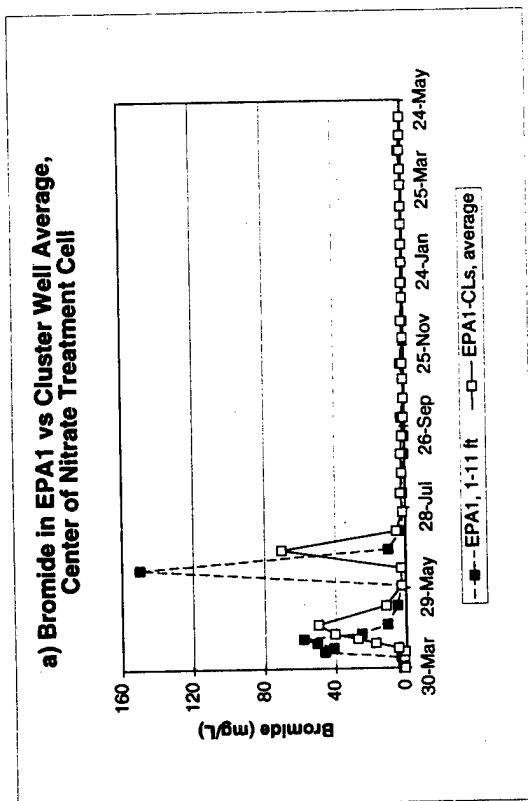


Figure 24. Comparison of Tracer Data in Conventional PVC Wells vs Cluster Well Averages

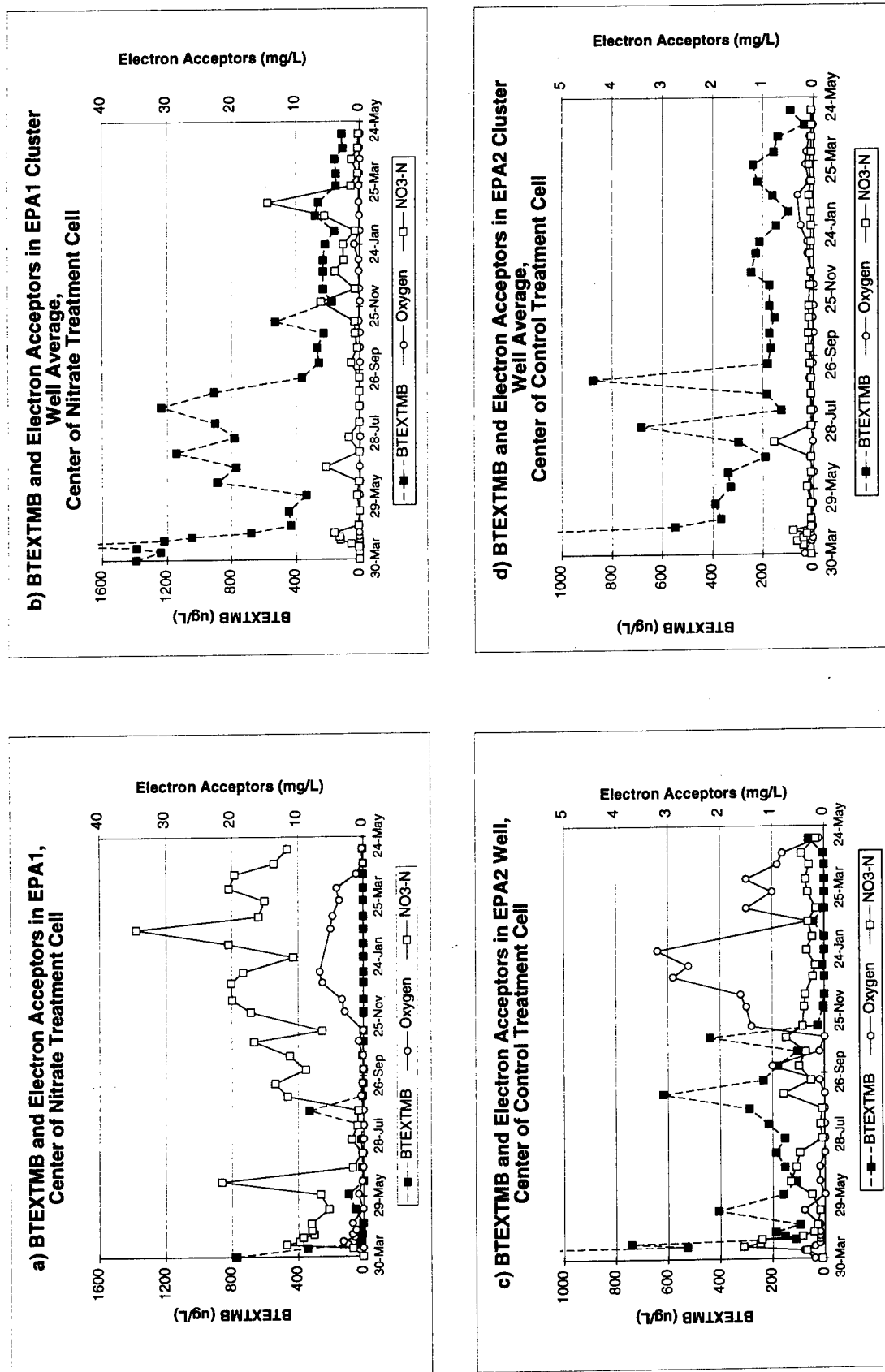


Figure 25. BTEXMTMB and Electron Acceptor Levels in a) EPA1 Monitoring Well, b) EPA1 Cluster Wells, c) EPA2 Monitoring Well, and d) EPA2 Cluster Wells

monitoring well screen through more transmissive zones above the contaminated interval, providing sufficient electron acceptors to facilitate biodegradation of BTEXTMB within the well itself. It is surprising that this effect is not negated by purging approximately ten well volumes from the well, as was done each time before sampling. Regardless of the exact mechanism, the extent of bioremediation can be clearly overestimated using the conventional monitoring wells. Because of this, the cluster wells were used (where available) to provide a more accurate representation of the aquifer environment.

b. Distribution of BTEXTMB and Electron Acceptors in Cluster Wells

Contaminant and electron acceptor profiles were complex, and varied both temporally and spatially for the two treatment cells. In the following section, the cluster well data are presented in graphical format, with graphs oriented analogous to the well locations shown in Figure 14. Contaminant data are summed as BTEXTMB and are shown in Figure 26; additional information on the individual isomers is available in Appendix C. It should be noted that the scale for the two profiles at the edges of the treatment cells is five times that of the profiles located in the centers of the treatment cells. In addition to this spatial difference, the BTEXTMB profiles (ie, concentration vs time) were very different for the different locations. Near the source area (Figure 26c), contaminant concentrations were high and did not change much during the entire project period. Because the tracer studies showed that flow from the Nitrate Cell was moving through this area, this indicates that residual saturation was probably present at this location, causing slow release of contaminants as water moved through the different levels. In contrast, the initial contaminant levels were much higher at the edge of the Control Cell, but diminished at a constant rate, except for some unusually high spike intervals which occurred during Jun-Sept and again in Oct (Figure 26a). The cause of these peak concentrations of BTEXTMB is unknown, but may be related to the high water table elevations occurring during these times (Figure 17). This effect was observed to a lesser extent in the cluster wells located in the centers of the treatment cells (Figure 26b, d). In the center of the Control Cell, BTEXTMB concentrations initially diminished rapidly and then more slowly with time (Figure 26b). This was also observed in the center of the Nitrate Cell, but the anomalous spikes were more apparent (Figure 26d). Also, BTEXTMB levels did not drop as quickly in the upper cluster well of the Nitrate Cell, indicating the presence of residual saturation or less water movement through this level. It was observed earlier from the tracer study that this well appeared to be somewhat isolated from the general recharge flow path. Comparison of Figures 2 and 15 reveal that the center of the Nitrate Cell was in an area which had previously contained plastic-covered infiltration trenches from the previous study on hydrogen peroxide, and this probably restricted water movement through this level. Because of the differences in ground surface elevations, the upper two cluster levels at the edge of the Control Cell were not located in contaminated intervals, whereas only the upper cluster level was uncontaminated at the center of the Control Cell and at the edge of the Nitrate Cell. BTEXTMB was

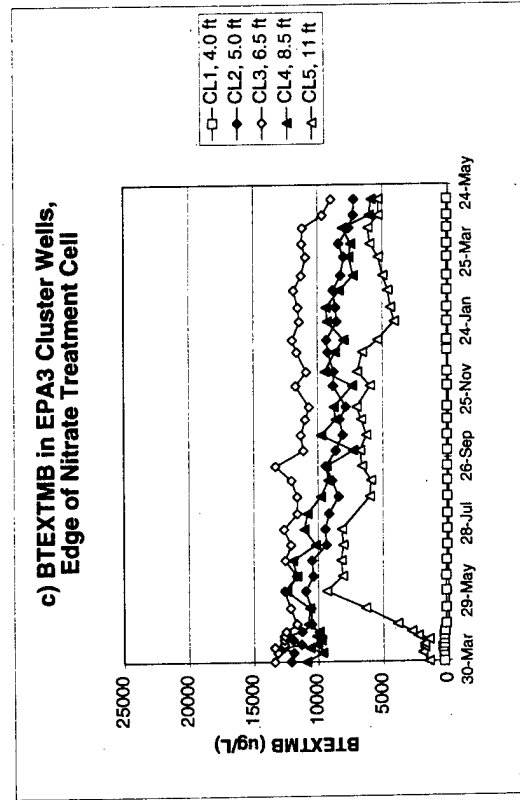
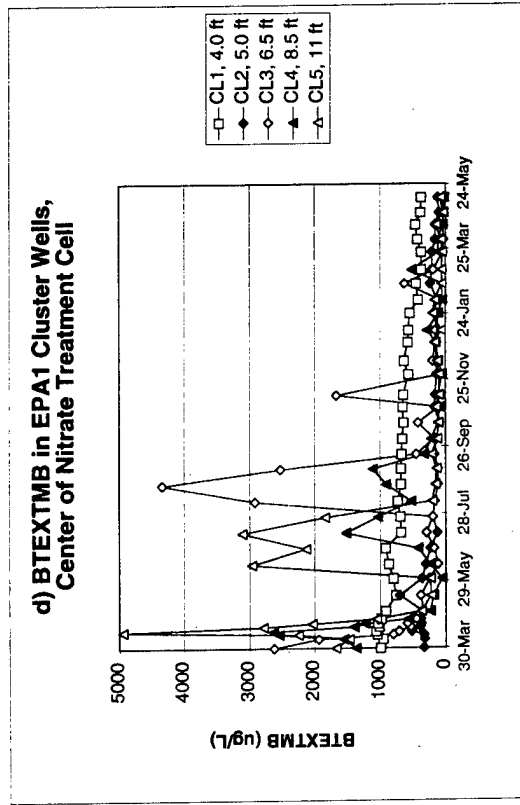
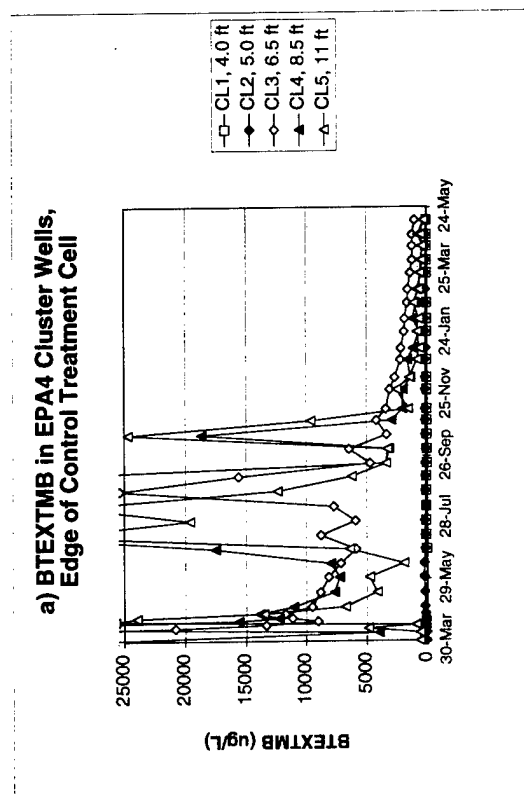
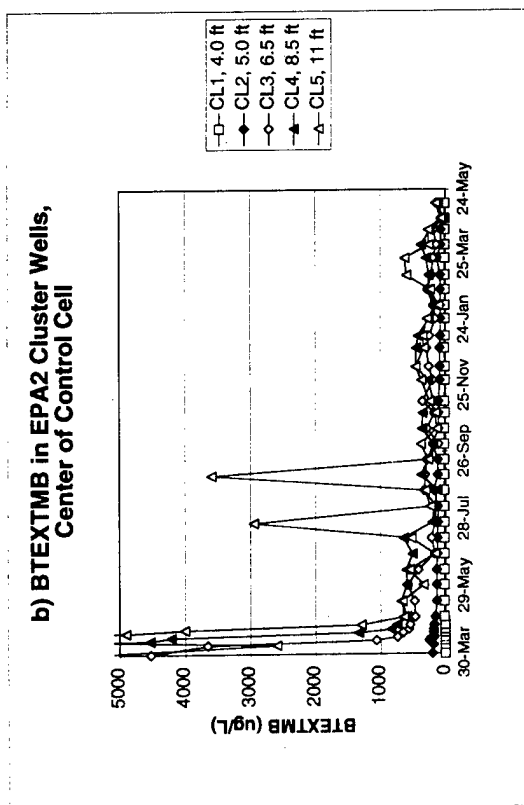


Figure 26. Aqueous BTEXTMB Profiles in Cluster Wells Located at a) Edge of Control Cell, b) Center of Control Cell, c) Edge of Nitrate Cell, and d) Center of Nitrate Cell

detected at all levels at the center of the Nitrate Cell.

Electron acceptor profiles were quite variable as well. Although nitrate was the only electron acceptor which was intentionally added to the recharge for the Nitrate Cell, other potential electron acceptors were either present in the unamended recharge, incorporated during sprinkler application, formed during transformation processes, or available in the aquifer solids. For example, oxygen was incorporated during sprinkler application of the recharge to both cells. In general, oxygen levels were below 0.5 mg/L in all of the cluster wells, with the exception of EPA4-CL1, which was often at or above the water table (Appendix C). Nitrate profiles are shown in Figure 27. Except for an occasional spike, nitrate was undetected at the edge and in the center of the Control Cell (Figure 27 a,b). The initial spike was probably due to leaching of soil nitrate and/or nitrification of fertilizer ammonia-nitrogen. There were much higher spikes of nitrate initially detected in all cluster levels in the center of the Nitrate Cell as result of nitrate application, but these levels diminished rapidly, and there were only occasional spikes until about Sept (Figure 27d). At first it was thought that the system was working as planned, with denitrification occurring in the upper contaminated interval. However, other sinks for nitrate were possible as well, and included uptake of nitrate by the vegetative cover and/or denitrification in the rhizosphere. Because of this, nitrate levels were increased to 20 mg/L $\text{NO}_3\text{-N}$ on July 15 (Figure 27d). This did not have an immediate effect, and nitrate breakthrough did not start until Oct. In contrast to this, nitrate levels did not ever break through appreciably at the edge of the Nitrate Cell (Figure 27c). In this case, nitrate removal was most likely due to denitrification within the contaminated intervals beneath the Nitrate Cell, limiting treatment efficiency at the edge. It should be noted that we did not design our study to treat the contaminated sediments at EPA3; these wells were used simply to assess water quality as recharge exited from beneath the Nitrate Cell. However, core analyses show that some treatment occurred at this location (Section IVD4). Part of this could have been due to simply increasing nitrogen availability as ammonia (discussed below) to stimulate other anaerobic biological processes.

Denitrification results in the loss of nitrate; it can also produce nitrite and nitrous oxide as intermediate electron acceptors. The nitrite profile was similar to that of the nitrate profile, with most of the compound being detected after Oct in all levels at the center of the Nitrate Cell (data not shown; see Appendix C). Nitrous oxide was not routinely measured, but was detected during the performance evaluations (Sections IVC and IVD). Neither of these compounds were present in the recharge water for the treatment cells. The presence of these intermediates support the hypothesis that nitrate removal was due at least in part to denitrification, and not just nitrate uptake by the vegetative cover. Again, it cannot be determined whether denitrification was limited to the rhizosphere; however, the absence of nitrite in the EPA3 cluster wells again indicates that denitrification was occurring in the contaminated intervals as well. Interestingly, ammonia nitrogen levels were significantly higher in the cluster wells at the center and the edge of the Nitrate Cell

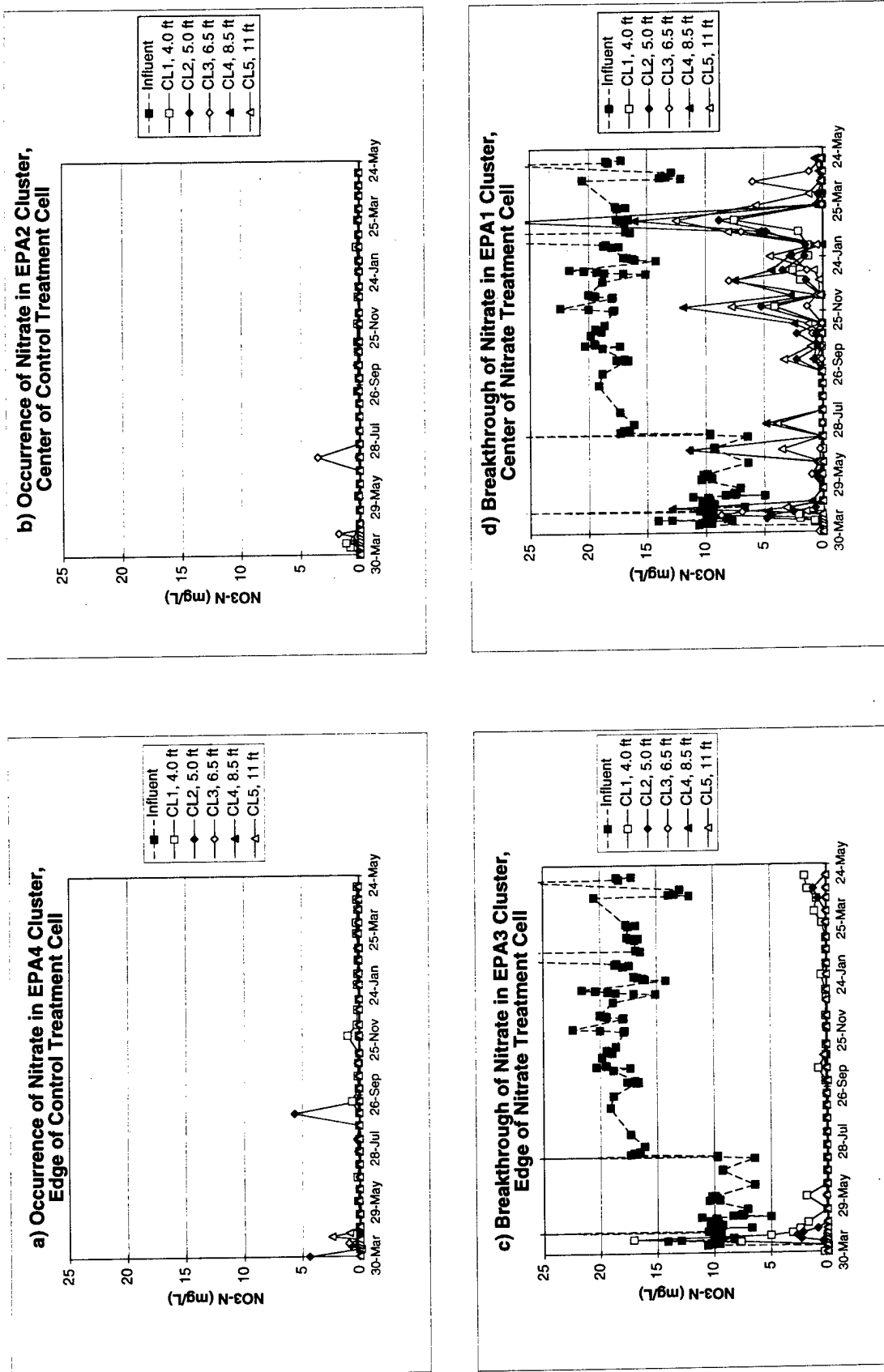


Figure 27. Occurrence and/or Breakthrough of Nitrate in Cluster Wells Located at a) Edge of Control Cell, b) Center of Control Cell, c) Edge of Nitrate Cell, and d) Center of Nitrate Cell

than in the cluster wells in the corresponding Control Cell (Figure 28). Ammonia nitrogen was not detected in the recharge waters for the two treatment cells. Although ammonia nitrogen is not an electron acceptor in this instance, it most likely results from dissimilatory reduction of nitrate to ammonia, which can occur when concentrations of electron acceptors are limited relative to the available organic carbon (Tiedje, 1988), as would be the case for these cluster wells. This process complements rather than competes with denitrification, and, from a standpoint of contaminant reduction, is in fact more beneficial. This is because dissimilatory nitrate reduction to ammonia provides more electron-accepting capacity than denitrification, since nitrate-nitrogen is reduced to a valence of -3 ($\text{NH}_4\text{-N}$) rather than 0 (N_2). Although dissimilatory nitrate reduction to ammonia can be carried out by different groups of bacteria than the regular denitrifiers, some bacteria can accomplish both. The high concentrations of ammonia nitrogen at the edge of the Nitrate Cell lend further support to the hypothesis that the nitrate and nitrite are being reduced during transport through the contaminated intervals beneath the Nitrate Cell.

Along with the obvious addition of nitrate in the sprinkler recharge for the Nitrate Cell, sulfate is also present in the recharge water for both cells at about 10 mg/L. Sulfate can also be used as an alternate electron acceptor, and there are numerous studies which show biodegradation of aromatic hydrocarbons under sulfate-reducing conditions (Grbic-Galic, 1989; Haag et al, 1991; Edwards et al, 1992; Beller et al, 1992, Coates et al, 1996). When sprinkler application first began, large amounts of sulfate were initially mobilized from the surface soil layers in both cells (Figure 29). Most of this mobilization was complete by about Jun, and sulfate levels declined to low levels by Sept in all locations except for EPA4, which showed anomalous sulfate spikes after this time (Figure 29a). These spikes are again coincident with the elevated water table and the high BTEXTMB levels, indicating that other surface layers were probably being contacted and depleted of sulfate. The decline of sulfate in the other locations may be due to clipping and decay of vegetative matter during the growing season, which can lead to sulfate utilization. Although sulfate concentrations varied significantly in all levels at the different locations after this time, some patterns became evident. For example, there was generally extensive sulfate breakthrough at EPA1, located in the center of the Nitrate Cell (Figure 29d). This would be expected if nitrate were being used preferentially to sulfate as the alternate electron acceptor. Sulfate concentrations again began to drop for all cluster well levels at all locations after Feb, possibly in response to biodegradation of the clipped and decaying organic matter as the growing season commenced again. In contrast, except for the surface uncontaminated layer, there was never much sulfate breakthrough at EPA3, located downgradient in the highly contaminated area (Figure 29c). This indicates that sulfate reduction is occurring within the contaminated intervals. Sulfate concentrations varied markedly at EPA2, located in the center of the Control Cell, but in general were correspondingly less than those for the Nitrate Cell cluster wells (Figure 29b). Because nitrate was not available, it appears that sulfate became the primary electron acceptor at this location. Further evidence is given by

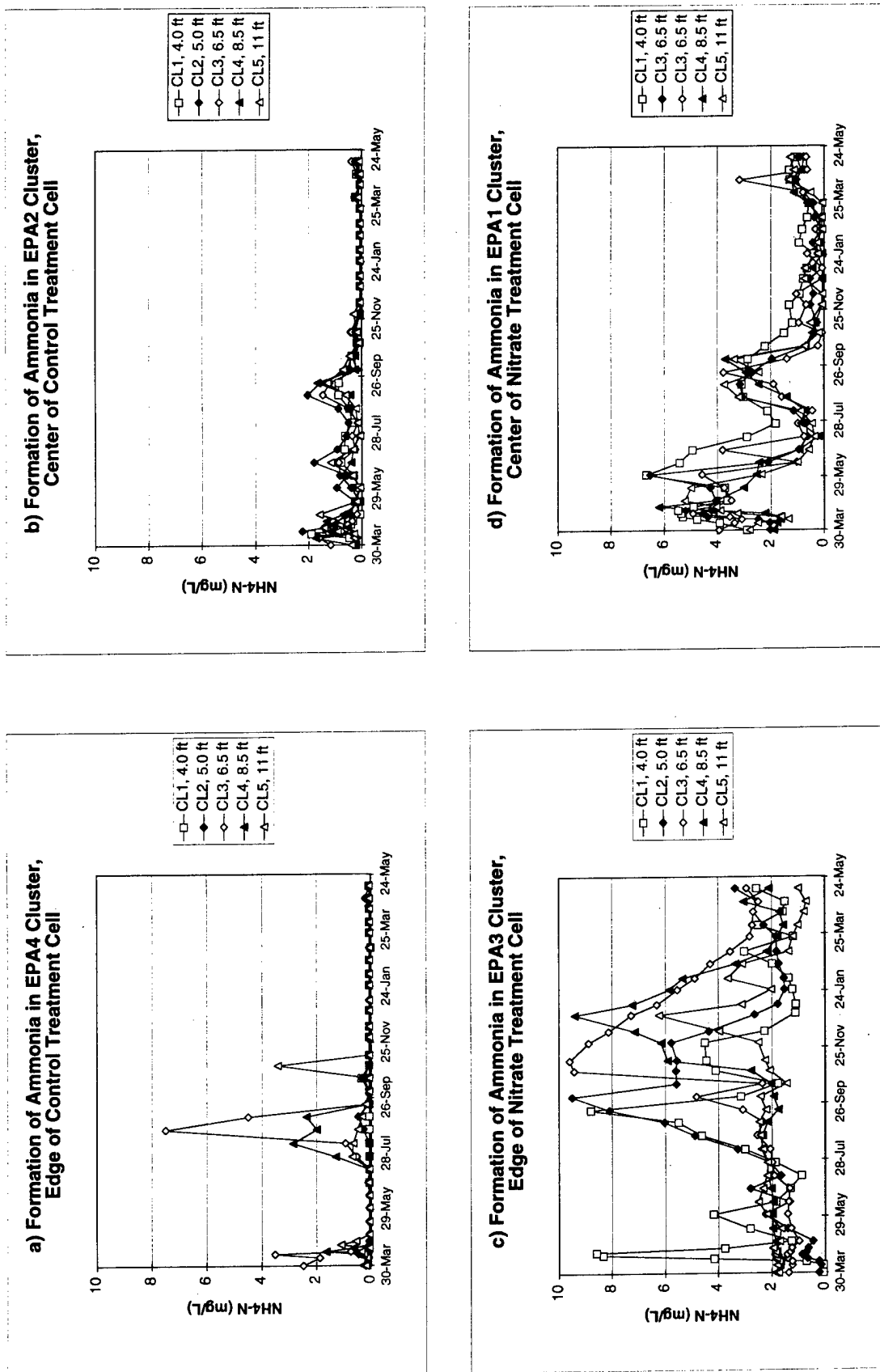


Figure 28. Formation of Ammonia-Nitrogen in Cluster Wells Located at a) Edge of Control Cell, b) Center of Control Cell, c) Edge of Nitrate Cell, and d) Center of Nitrate Cell

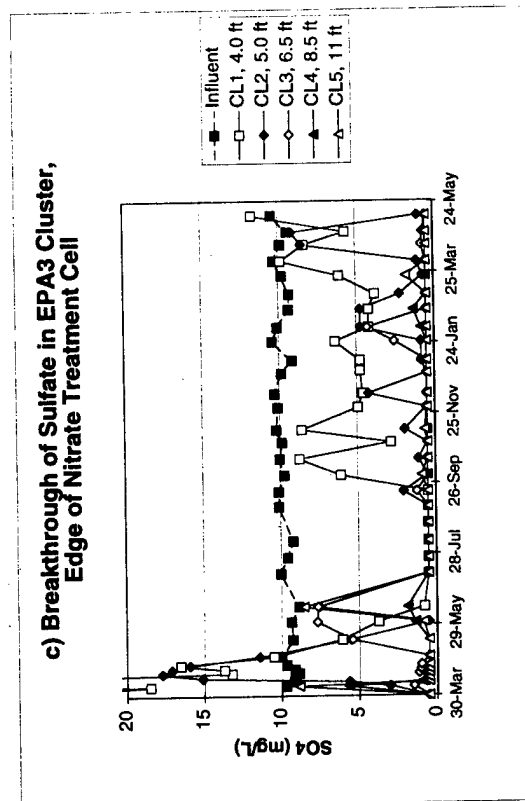
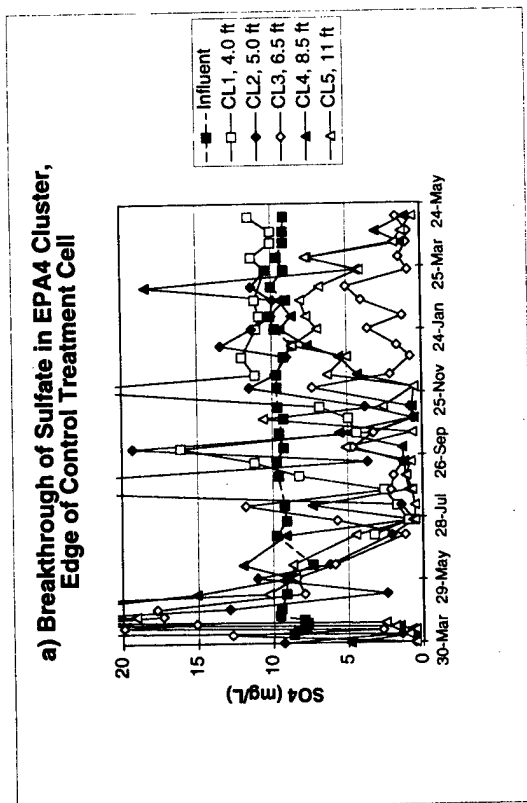
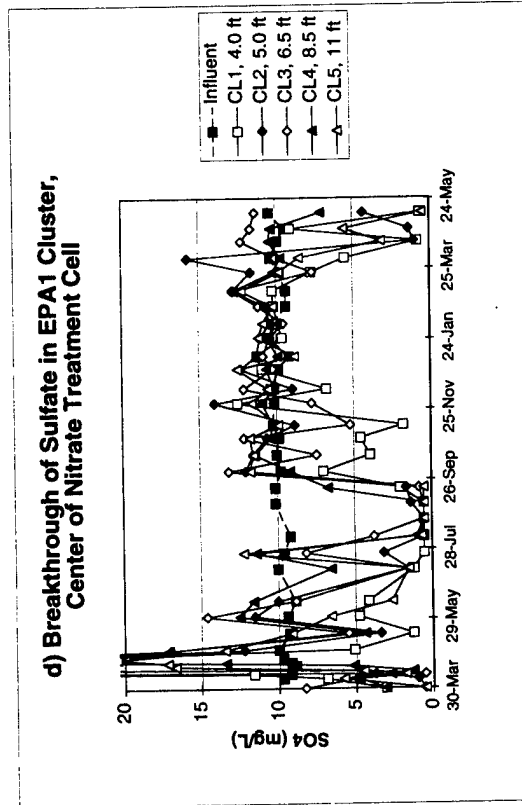
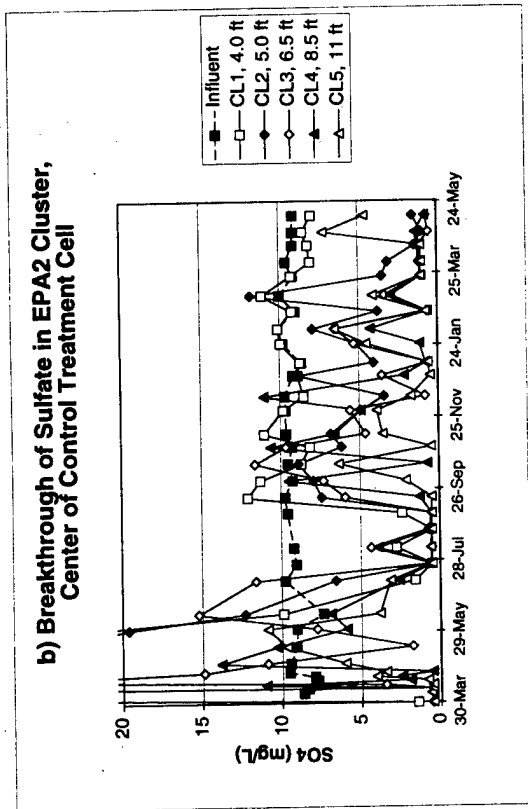


Figure 29. Breakthrough of Sulfate in Cluster Wells Located at a) Edge of Control Cell, b) Center of Control Cell, c) Edge of Nitrate Cell, and d) Center of Nitrate Cell

the field data for thiosulfate, a possible intermediate in sulfate reduction, which we began to analyze for in Feb. Higher concentrations were detected in the cluster wells at both the center and edge of the Control Cell than in the corresponding Nitrate Cell locations (Figure 30). These concentrations were generally high when sulfate concentrations were low, and vice versa. Thiosulfate was not detected in the recharge water.

Ferric iron can also serve as an alternate electron acceptor for the biodegradation of aromatic hydrocarbons under iron-reducing conditions (Lovely et al, 1989; Lovely et al, 1996). In addition, ferrous iron can also stimulate toluene biodegradation under sulfate-reducing conditions (Beller et al, 1992). Although iron was not detected in the recharge water, it was available in the soil and ground water. As with sulfate, continuous sprinkler application of recharge water caused an initial leaching of iron from the surface soils (Figure 31). The iron is measured as soluble iron, and can include both ferric and ferrous iron. However, given the neutral pH of the ground water, most of this iron is probably in the reduced state. Therefore, high levels of soluble iron can indicate both leaching from surface soils and the occurrence of iron-reducing conditions. In the case of EPA4, located at the edge of the Control Cell, iron concentrations dropped but then exhibited the same anomalous spike as was observed with BTEXTMB and sulfate (Figure 31a). Again, this is most likely due to leaching of these components out of previously uncontacted surface soils, since these spikes correspond to high water tables. In most cases, soluble iron levels decreased during the pilot demonstration project. However, soluble iron levels were higher and decreased more slowly for the upper cluster well at the center of the Nitrate Cell (Figure 31d). This level also had higher BTEXTMB concentrations and was, as discussed previously, somewhat isolated from the general recharge flow path. It cannot be determined whether iron reduction was more prevalent in the Nitrate Cell compared to the Control Cell, since the original electron acceptor was probably localized to aquifer solids and could not be measured. However, it is of interest to note that soluble iron levels were high in the lower three levels at the edge of the Nitrate Cell, which contained significant BTEXTMB contamination (Figure 31c). Because this does not follow the other patterns of rapidly declining iron concentrations, it may indicate that iron reduction is occurring at or upgradient of this location. Because this also coincided with sulfate reduction, the mechanism of iron reduction could be either biotic or abiotic.

c. Organic Acid Intermediates

Periodically, selected analyses would be done to better evaluate the role of biodegradation during the pilot demonstration project. An analysis of organic acids in the cluster wells was conducted during the second tracer study in Jun 94 to see if intermediates from the biodegradation of aromatic hydrocarbons could be detected. Water samples were collected in 160-mL serum bottles and preserved with 10% Na_3PO_4 . Analyses for phenols, aliphatic acids, and aromatic acids were

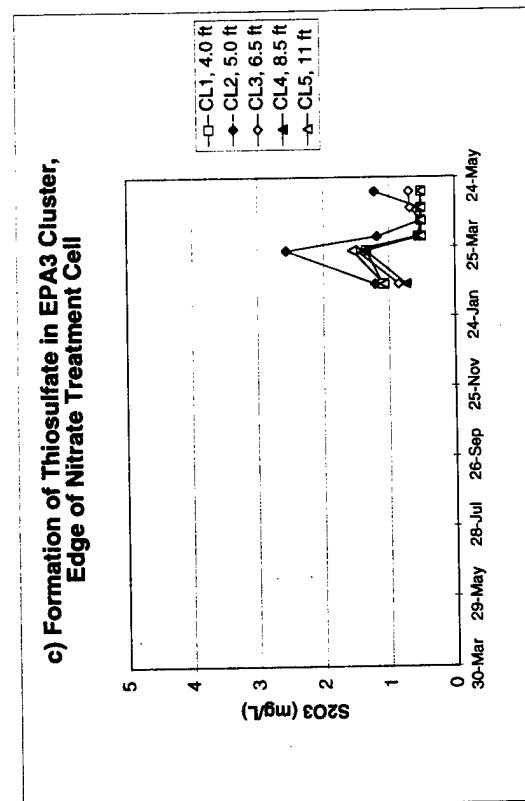
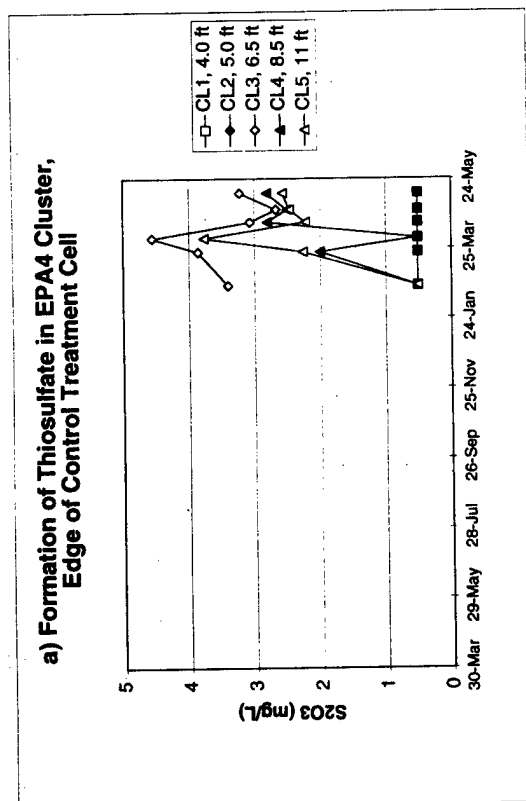
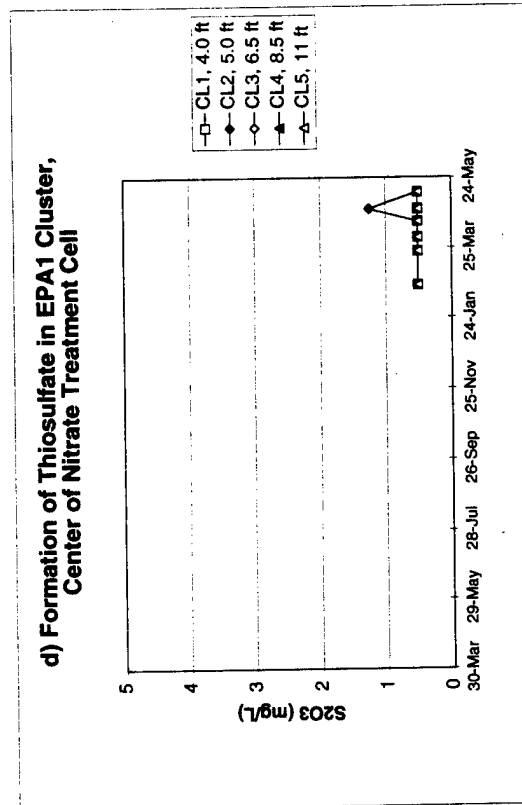
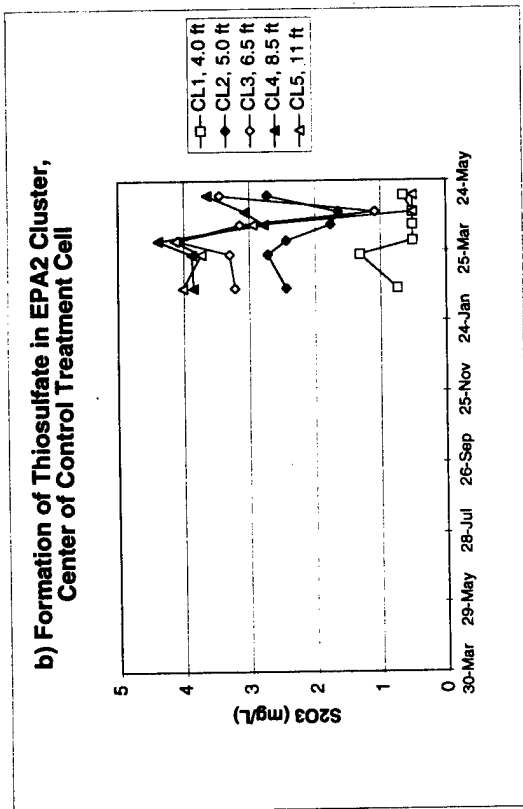


Figure 30. Formation of Thiosulfate in Cluster Wells Located at a) Edge of Control Cell, b) Center of Control Cell, c) Edge of Nitrate Cell, and d) Center of Nitrate Cell

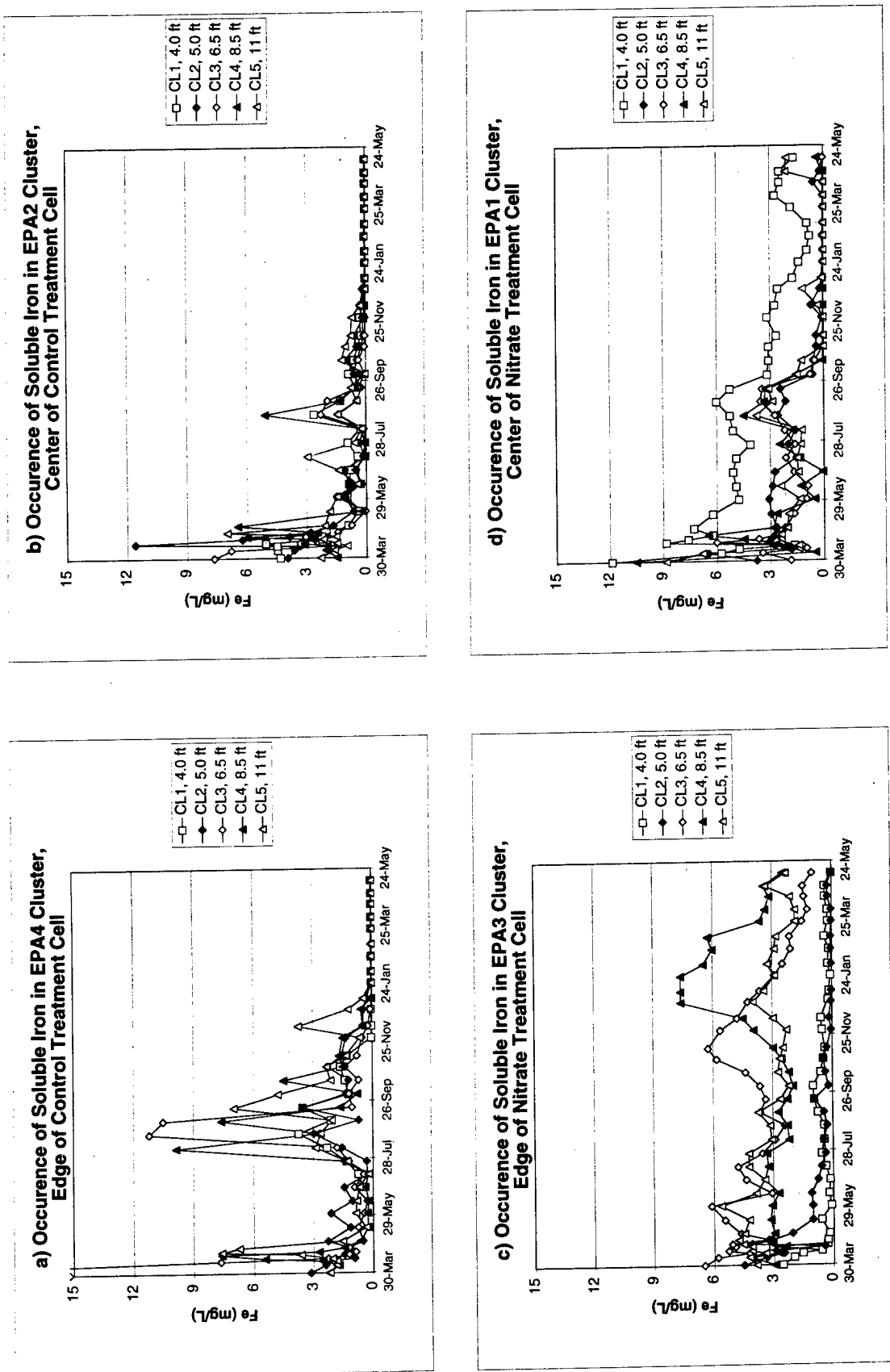


Figure 31. Occurrence of Soluble Iron in Cluster Wells Located at a) Edge of Control Cell, b) Center of Control Cell, c) Edge of Nitrate Cell, and d) Center of Nitrate Cell

performed based on modifications from earlier procedures (Folgelqvist et al, 1980). The samples were then acidified, extracted with methylene chloride, and derivatized with pentafluorobenzyl bromide according to RSKERL SOP 177. The derivatized extracts were chromatographed on a 0.25 mm J&W DB5-MS capillary column with a 0.25 μ m film thickness and a temperature program of 100°C to 300°C (16 minutes) at 6°C/minute. Analyses were conducted using a Finnegan 4615 GC/MS with a scan of 42 to 550 m/z in 0.5 sec. The only compound detected in the recharge water was benzoic acid at 10.3 μ g/L; this was assumed to be a method contaminant and sample values were therefore corrected for this amount. The data for the cluster wells are shown in Table 12. Most of the hydrocarbon breakdown products were detected in the cluster wells at the edge of the Nitrate Cell, with concentrations up to and exceeding 500 μ g/L (Table 12). Although much lower in concentration, the next most prevalent group of breakdown products was found in the EPA1 cluster wells, at the center of the Nitrate Cell. Operation of the pilot demonstration project had essentially reversed the regional ground water flow by this time (see Figure 18), and so it is doubtful that the breakdown products detected at the center of the Nitrate Cell originated from the source area. Similarly, although contaminant concentrations were highest at the edge of the Control Cell (EPA4), there were no detectable breakdown products at this location, and concentrations were also low in the center of the Control Cell (Table 12). This indicates that biodegradation was indeed occurring in the Nitrate Cell, and perhaps to a greater extent than in the Control Cell. However, it is also possible that processes other than denitrification (eg, sulfate reduction) may have been occurring to similar extents in the Control Cell, but that these intermediates were either not produced or were metabolized more quickly than the parent compounds.

C. INTERIM PERFORMANCE EVALUATION

1. General System Performance

An Interim Performance Evaluation was conducted Aug 19-30, 1994, approximately 120 days after sprinkler application first began. The purpose of this evaluation was to gather additional soil and water quality information to evaluate the performance of the pilot demonstration project for the first one-third of the operating period. During this time, approximately 27 feet of recharge had been added to the treatment cells, with 94 kg nitrate-nitrogen added to the Nitrate Cell. General system performance had been quite good, with few operational problems, no flooding or ponding of the recharge, and no nitrate being detected in the down-gradient wells (Appendices B, C). However, there was concern regarding the amount of applied nitrate which was actually being transported to the contaminated interval. Continuous sprinkler application caused increased vegetative growth in both cells, and each cell was mowed approximately once every 2 weeks. The grass clippings were not collected and discarded, but left in place. Vegetative growth had the potential for creating two additional sinks for nitrate: (1) nitrate uptake by the vegetation, for use as

TABLE 12. CONCENTRATIONS OF MONOAROMATIC HYDROCARBON BREAKDOWN PRODUCTS IN CLUSTER WELLS,
COLLECTED 6/94 DURING OPERATION OF PILOT DEMONSTRATION PROJECT (CONCENTRATIONS IN µg/L)

Monoaromatic Hydrocarbon Breakdown Product	Hypothesized Parent Compound	Nitrate Cell, Center					Nitrate Cell, Edge					Control Cell, Center					Control Cell, Edge				
		1-1	1-2	1-3	1-4	1-5	3-1	3-2	3-3	3-4	3-5	2-1	2-2	2-3	2-4	2-5	4-1	4-2	4-3	4-4	4-5
Benzoic Acid	Toluene	<0.1	<0.1	<0.1	<0.1	<0.1	21.3	12.6	7.5	0.8	<0.1	0.7	<0.1	0.7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phenylacetic acid	Ethylbenzene	17.8	<0.1	<0.1	16.5	47.8	18.7	20.3	128.0	314.0	11.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
<i>p</i> -Methylbenzoic acid	<i>p</i> -Xylene	14.7	<0.1	<0.1	11.4	13.7	16.5	12.4	94.1	162.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
<i>m</i> -Methylbenzoic acid	<i>m</i> -Xylene	<0.1	<0.1	<0.1	<0.1	<0.1	751.0	322.0	152.0	23.6	10.6	10.2	9.7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
<i>o</i> -Methylbenzoic acid	<i>o</i> -Xylene	<0.1	<0.1	<0.1	<0.1	11.1	14.6	14.2	138.0	328.0	40.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
3,5-Dimethylbenzoic acid	1,3,5-Trimethylbenzene (Mesitylene)	14.1	11.7	8.7	8.1	8.2	59.0	30.3	144.0	165.0	12.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2,4-Dimethylbenzoic acid	1,2,4-Trimethylbenzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	29.0	65.7	38.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2,5-Dimethylbenzoic acid	(Pseudocumene)	<0.1	<0.1	<0.1	<0.1	<0.1	16.4	<0.1	37.0	132.0	31.7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
3,4-Dimethylbenzoic acid		20.7	51.2	42.7	27.5	16.1	14.8	19.7	101.0	170.0	158.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2,3-Dimethylbenzoic acid	1,2,3-Trimethylbenzene	<0.1	<0.1	<0.1	<0.1	<0.1	22.5	10.6	39.2	134.0	50.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2,6-Dimethylbenzoic acid		<0.1	<0.1	<0.1	8.8	9.6	27.6	17.5	54.4	23.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
3-Phenylpropanoic acid	Propylbenzene	<0.1	<0.1	<0.1	<0.1	<0.1	30.4	13.7	30.8	18.8	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2-Phenylpropanoic acid	Isopropylbenzene	<0.1	<0.1	<0.1	<0.1	<0.1	8.6	<0.1	7.8	40.3	21.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
<i>p</i> -Tolylacetic acid	<i>p</i> -Methylethylbenzene	<0.1	<0.1	12.0	8.7	<0.1	44.2	20.2	195.0	1400.0	376.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
<i>p</i> -Ethylbenzoic acid		<0.1	<0.1	<0.1	<0.1	<0.1	12.4	13.1	88.0	93.4	17.8	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
<i>m</i> -Tolylacetic acid	<i>m</i> -Methylethylbenzene	<0.1	8.6	<0.1	8.7	10.3	17.9	9.3	99.8	757.0	220.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
<i>o</i> -Tolylacetic acid	<i>o</i> -Methylethylbenzene	<0.1	<0.1	<0.1	11.1	12.8	285.0	29.0	103.0	742.0	153.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2,4,6-Trimethylbenzoic acid	1,2,3,5-Tetramethylbenzene	<0.1	<0.1	<0.1	<0.1	<0.1	85.9	26.3	223.0	845.0	167.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2,4,5-Trimethylbenzoic acid	1,2,4,5-Tetramethylbenzene	<0.1	<0.1	<0.1	<0.1	<0.1	61.8	132.0	553.0	478.0	125.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

a nitrogen fertilizer source, and (2) nitrate utilization by denitrifying bacteria in the rhizosphere, with the decaying vegetation providing the organic carbon as electron donor. Because of this, lysimeter samples were taken during the Interim Performance Evaluation to provide information on the extent of nitrate transport.

2. Lysimeter Samples

An attempt was made to quantify the amount of nitrate passing the root zone (0.0 - 0.5 feet below ground surface) by installing suction lysimeters in the underlying vadose zone. The sprinkler system was shut down prior to installation of the lysimeters to avoid channelling of infiltrate down the casings. In addition, the holes were backfilled with bentonite as a precautionary measure. The lysimeters were initially installed 1.3-1.5 feet below ground surface adjacent to core locations 80W, 80X, 80Y, 80Z, and 80ZA (Figure 32). However, we were unable to obtain water samples from locations 80X, 80Y, and 80ZA, and therefore these lysimeters were reinstalled 2.3-2.5 feet below ground surface. For some of the lysimeters, samples were taken on consecutive days to evaluate nitrate loss with time. Breakthrough of nitrate varied significantly across the nitrate cell, being about 50-60% in two locations and 4-6% in three others (Table 13). Those locations showing the lowest amount of nitrate also showed rapid loss with time, indicating that much of the loss was occurring at least one to two feet below ground surface. It is interesting to note that in each location, nitrate concentrations decreased with time and ammonium concentrations (except for location 80W) increased with time. This trend is consistent with the hypothesis that dissimilatory nitrate reduction to ammonia is occurring. Also, the three locations with the lowest nitrate concentrations had the highest ammonium concentrations. If it is assumed that the ammonium nitrogen arises from nitrate reduction, then the total nitrogen breakthrough more accurately depicts the percentage of nitrate which is not being taken up by the vegetation. In this case, nitrogen breakthrough increases to 50-70% in two locations and 15-20% in the other three. Because these data were taken during August, essentially in the middle of the growing season, they represent a worst-case scenario for nitrate loss. The data therefore indicate that, during most of the pilot demonstration period thus far, a significant percentage of the applied nitrogen was being transported to below one to two feet and presumably into the contaminated intervals.

3. Ground Water Samples

As with the initial site characterization, water samples were again collected from the POL wells and from selected points below ground surface using the geoprobe. Samples from the wells were analyzed for the constituents that were routinely monitored, as well as TOC, methane, and nitrous oxide. These data are shown in Table 2. Perhaps the most important aspect of this dataset is that nitrate, nitrite, and nitrous oxide concentrations were generally at or below the detection limit in water samples taken from wells both within and outside the pilot cells. Operation of

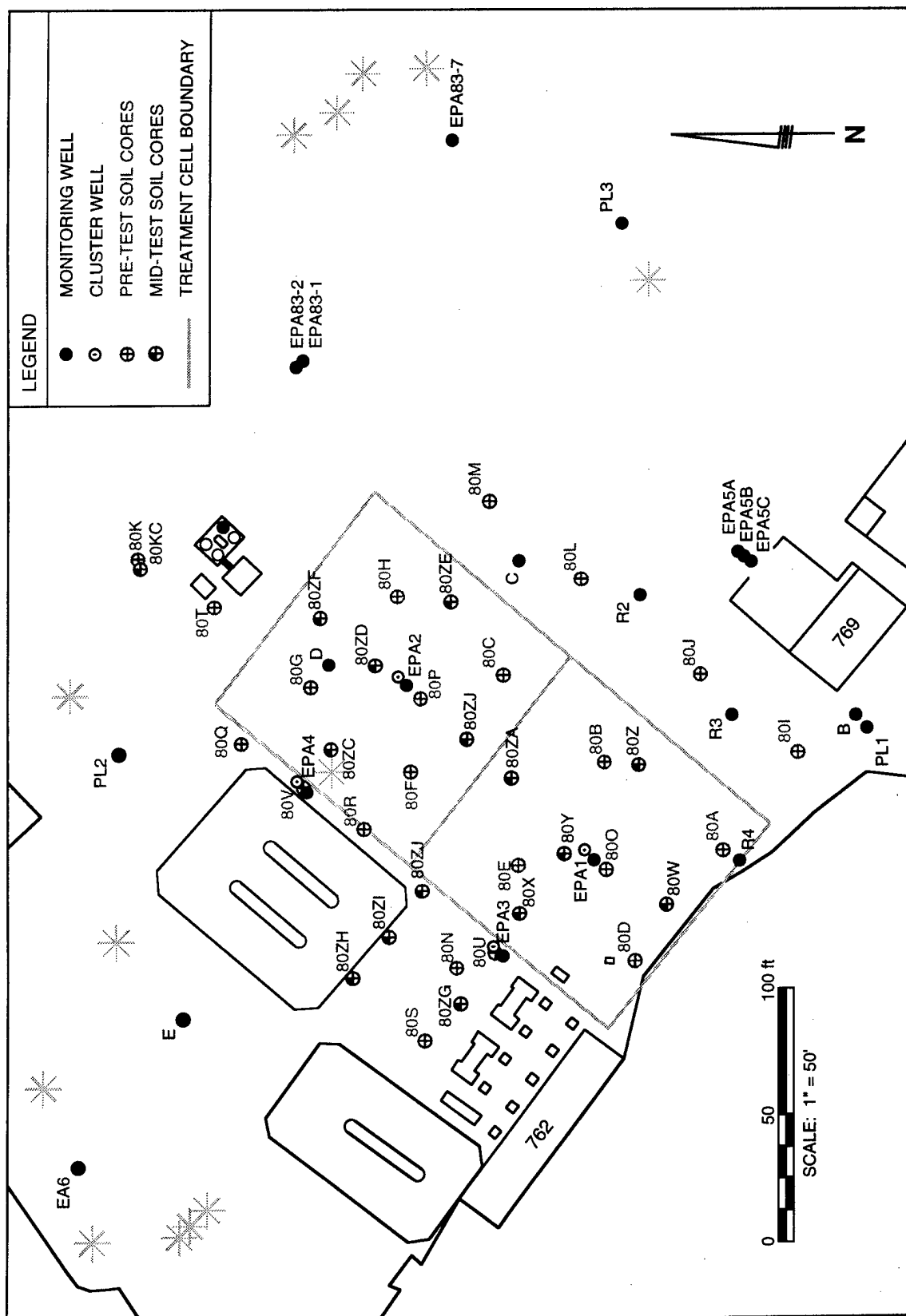


TABLE 13. NITROGEN DATA FOR WATER SAMPLES OBTAINED FROM SOIL LYSIMETERS
INSTALLED IN NITRATE CELL DURING INTERIM PERFORMANCE EVALUATION

Lysimeter	Depth	Date/Time	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	% NO ₃ -N Breakthrough	% NO ₃ -N, NO ₂ -N Breakthrough	% Total Nitrogen Breakthrough
80W	1.3-1.5	8/19/94 12:20	7.80	0.14	0.64	48.0	48.8	52.8
80W	1.3-1.5	8/20/94 8:08	7.53	0.17	0.36	46.3	47.4	49.6
80W	1.3-1.5	8/20/94 14:24	6.28	0.17	0.18	38.6	39.7	40.8
80X	2.3-2.5	8/20/94 7:51	0.72	0.23	2.38	4.4	5.8	20.5
80X	2.3-2.5	8/20/94 14:28	0.05	0.11	3.68	0.3	1.0	23.6
80Y	2.3-2.5	8/20/94 7:58	0.64	0.08	1.93	3.9	4.4	16.3
80Z	1.3-1.5	8/19/94 12:20	0.91	0.05	1.66	5.6	5.9	16.1
80Z	1.3-1.5	8/20/94 8:12	0.12	0.05	2.45	0.7	1.0	16.1
80Z	1.3-1.5	8/20/94 14:09	0.10	0.05	3.52	0.6	0.9	22.6
80ZA	2.3-2.5	8/20/94 8:03	10.30	0.33	0.87	63.3	65.4	70.7
80ZA	2.3-2.5	8/20/94 14:15	8.96	0.31	1.08	55.1	57.0	63.7

the pilot system did not appear to have caused any significant contamination of the bulk ground water by nitrate or its degradation products, even after doubling the influent nitrate concentrations.

A geoprobe was used to collect water samples at three depths (3.5-5.0, 6.5-8.0, and 9.5-11.0 feet below ground surface) next to core locations 80KC, 80X, 80Z, 80ZA, 80ZB, 80ZC, 80ZE, 80ZF, and 80ZG (Figure 32). These data are shown in Table 14. Ground water throughout the site was still contaminated, with dissolved BTEXTMB concentrations generally increasing in the lower depths. This is probably due to the increased vertical hydraulic gradient brought about by sustained infiltration, causing the leaching of aqueous BTEXTMB from the upper contaminated zones. These data were compared with those from the geoprobe samples taken prior to start-up of the pilot test to evaluate whether nitrate addition has caused any effect on aqueous BTEXTMB concentrations. This was done by averaging total BTEXTMB concentrations for a given level across either the nitrate cell or the control cell. This is by necessity a rough comparison, since geoprobe locations do not match up exactly with those done earlier. There was an average removal of about 83% of total dissolved BTEXTMB at each level, except for the lower two levels in the nitrate cell (Table 15). These data show that nitrate addition had not yet enhanced BTEXTMB removal relative to the control cell. This was not as expected, but the data are extremely variable, with coefficients of variation (standard deviation/mean) averaging 100%. The described analysis was done to provide a direct comparison of water quality between the treatment cells, and represents a conventional approach. A better way to evaluate the data would be to examine changes in mass ratios of selected components. This would eliminate some of the variability induced by "pockets" of contamination dispersed across given levels. This was done for mesitylene (1,3,5-trimethylbenzene) and 1,2,3-trimethylbenzene. Both isomers are similar with respect to physical chemistry, but mesitylene is generally degraded under denitrifying conditions whereas 1,2,3-trimethylbenzene is recalcitrant (Hutchins, unpublished data). Mass ratios were calculated by dividing the concentrations of each isomer by the concentration of total BTEXTMB; coefficients of variation averaged 60% using this approach. Considering all of the data at all of the levels, the average ratio of mesitylene:1,2,3-trimethylbenzene was found to be 0.91 ± 0.32 for the Nitrate Cell and 0.77 ± 0.14 for the Control Cell before the pilot test. After 4 months operation, the ratio dropped to 0.49 ± 0.46 for the Nitrate Cell and remained at 0.84 ± 0.38 for the Control Cell. Preferential microbial degradation of mesitylene is the most likely explanation. It should be emphasized that the underlying mechanism for enhanced degradation cannot be discerned; enhanced degradation through other processes such as sulfate reduction could possibly contribute just as much as that through denitrification.

There did appear to be some migration of nitrate infiltrate water to the Control Cell. This is shown by the presence of high levels of nitrite and nitrous oxide in the upper levels of 80ZA (at the edge of the Nitrate Cell) and in the lowest level of 80ZB (at the adjacent edge of the Control Cell). This crossover probably occurred

TABLE 14. GEOPROBE WATER QUALITY DATA FOR EGLIN AFB SITE DURING INTERIM PERFORMANCE EVALUATION, 8/94

Area	Sample	Grade Elev. (ft MSL)	Bot. Screen (ft from GS)	Top Screen (ft from GS)	Bot. Screen (ft MSL)	Top Screen (ft MSL)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	TOC (mg/L)
Uncontaminated Control	80KC-1	12.51	5.00	3.50	7.51	9.01	4.94	2.4	2.70	2.4	4.1	0.64	<0.05	0.06	<0.05	2.1	1.3
	80KC-2	12.51	8.00	6.50	4.51	6.01	5.83	0.4	3.13	1.2	3.1	<0.05	<0.05	0.15	<0.05	1.8	5.3
	80KC-3	12.51	11.00	9.50	1.51	3.01	5.95	0.4	13.50	1.3	7.0	<0.05	<0.05	0.66	<0.05	<0.5	12.3
Nitrate Cell	80W-1	11.86	5.00	3.50	6.86	8.36	6.72	0.9	1.59	<0.5	11.0	1.70	0.28	1.74	1.06	5.0	9.5
	80W-2	11.86	8.00	6.50	3.86	5.36	6.60	0.5	6.45	0.9	9.7	<0.05	<0.05	0.80	1.01	5.5	14.9
	80W-3	11.86	11.00	9.50	0.86	2.36	6.02	0.6	13.50	1.1	9.4	<0.05	0.10	3.74	0.26	9.0	9.0
	80X-1	12.42	5.00	3.50	7.42	8.92	6.79	0.7	2.62	2.6	9.1	<0.05	<0.05	0.77	<0.05	<0.5	19.1
	80X-2	12.42	8.00	6.50	4.42	5.92	6.79	0.6	2.86	2.3	8.9	<0.05	<0.05	1.30	0.06	<0.5	20.1
	80X-3	12.42	11.00	9.50	1.42	2.92	6.45	0.7	4.08	15.6	8.6	<0.05	<0.05	1.59	0.06	<0.5	18.0
	80Z-1	11.03	5.00	3.50	6.03	7.53	6.92	0.5	6.21	0.7	9.5	<0.05	<0.05	4.07	1.49	7.1	14.5
	80Z-2	11.03	8.00	6.50	3.03	4.53	6.64	0.5	7.60	0.7	9.4	<0.05	<0.05	3.35	1.37	<0.5	12.8
	80Z-3	11.03	11.00	9.50	0.03	1.53	6.06	0.3	10.20	9.2	9.5	<0.05	<0.05	4.32	0.59	<0.5	22.5
Control Cell	80ZA-1	11.98	5.00	3.50	6.98	8.48	6.65	0.4	1.59	0.8	9.9	0.62	2.56	0.39	0.39	10.2	14.8
	80ZA-2	11.98	8.00	6.50	3.98	5.48	6.75	0.6	2.03	<0.5	9.0	0.09	1.03	1.35	0.24	9.5	9.9
	80ZA-3	11.98	11.00	9.50	0.98	2.48	6.52	0.5	6.21	<0.5	9.3	0.07	<0.05	1.97	0.40	4.9	15.4
	80ZB-1	12.44	5.00	3.50	7.44	8.94	6.12	0.4	5.59	<0.5	11.8	<0.05	<0.05	0.80	<0.05	<0.5	36.6
	80ZB-2	12.44	8.00	6.50	4.44	5.94	6.50	0.4	2.54	<0.5	9.9	<0.05	<0.05	1.40	0.15	4.3	14.6
	80ZB-3	12.44	11.00	9.50	1.44	2.94	6.64	0.4	3.73	<0.5	8.8	<0.05	2.73	2.15	0.37	8.9	12.5
	80ZC-1	13.81	5.00	3.50	8.81	10.31	6.27	1.0	44.30	0.7	10.4	<0.05	<0.05	1.23	<0.05	<0.5	34.3
	80ZC-2	13.81	8.00	6.50	5.81	7.31	6.21	0.5	21.10	0.8	10.1	<0.05	<0.05	0.49	0.05	<0.5	16.6
	80ZC-3	13.81	11.00	9.50	2.81	4.31	6.24	0.3	5.28	1.0	10.1	<0.05	<0.05	0.07	0.05	<0.5	13.1
Source Area	80ZE-1	12.22	5.00	3.50	7.22	8.72	6.59	0.2	2.03	<0.5	9.5	<0.05	<0.05	0.22	0.08	2.7	5.1
	80ZE-2	12.22	8.00	6.50	4.22	5.72	6.48	0.4	1.10	<0.5	9.1	<0.05	<0.05	0.28	0.38	<0.5	4.4
	80ZE-3	12.22	11.00	9.50	1.22	2.72	6.38	0.4	3.32	<0.5	9.3	<0.05	<0.05	0.93	0.09	<0.5	7.9
	80ZF-1	12.74	5.00	3.50	7.74	9.24	6.62	1.2	1.10	0.7	10.0	0.23	<0.05	<0.05	<0.05	9.0	2.6
	80ZF-2	12.74	8.00	6.50	4.74	6.24	6.57	0.3	1.42	<0.5	10.0	<0.05	<0.05	<0.05	0.08	<0.5	6.8
	80ZF-3	12.74	11.00	9.50	1.74	3.24	6.75	0.2	2.24	0.8	10.0	<0.05	<0.05	<0.05	0.15	2.8	6.3
	80ZG-1	13.20	5.00	3.50	8.20	9.70	6.34	0.8	6.00	0.7	2.2	<0.05	<0.05	3.38	<0.05	<0.5	16.3
	80ZG-2	13.20	8.00	6.50	5.20	6.70	6.13	0.5	3.85	0.8	3.2	<0.05	<0.05	1.83	<0.05	0.6	12.2
	80ZG-3	13.20	11.00	9.50	2.20	3.70	6.16	0.4	3.96	0.7	2.7	<0.05	<0.05	2.86	<0.05	<0.5	20.0

TABLE 14 (cont). GEOPROBE WATER QUALITY DATA FOR EGLIN AFB SITE DURING INTERIM PERFORMANCE EVALUATION, 8/94

Area	Sample	CH ₄ (mg/L)	N ₂ O (mg/L)	BZ (µg/L)	TOL (µg/L)	ETBZ (µg/L)	PXYL (µg/L)	MXYL (µg/L)	OXYL (µg/L)	MESIT (µg/L)	PSCU (µg/L)	TMB (µg/L)	BTEXTMB (µg/L)
Uncontaminated Control	80KC-1	0.00	0.012	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
	80KC-2	0.91	<0.001	<1.0	4.6	22.8	10.7	9.4	9.7	9.0	19.4	5.6	91
	80KC-3	16.00	<0.001	3.5	5.5	66.3	349.0	941.0	1.0	78.1	201.0	82.8	1728
Nitrate Cell	80W-1	0.39	0.166	<1.0	<1.0	1.8	3.1	6.1	1.7	2.9	4.2	47.8	68
	80W-2	3.13	0.001	<1.0	<1.0	16.1	20.0	41.1	1.1	47.1	100.0	27.7	253
	80W-3	0.13	<0.001	<1.0	<1.0	2.0	4.5	4.2	4.5	3.2	47.1	23.2	89
	80X-1	4.76	<0.001	1.7	<1.0	22.7	73.7	69.6	63.1	29.3	74.1	40.7	375
	80X-2	5.79	<0.001	81.0	49.6	1080.0	1160.0	2810.0	705.0	160.0	534.0	260.0	6840
	80X-3	16.20	<0.001	69.4	2.9	452.0	513.0	171.0	63.9	19.1	627.0	44.4	1963
	80Z-1	5.79	<0.001	<1.0	1.0	3.6	7.0	4.7	1.5	1.4	8.4	6.8	34
	80Z-2	2.77	<0.001	<1.0	1.5	16.7	28.8	48.6	9.9	19.4	58.6	31.5	215
	80Z-3	3.78	<0.001	1.0	5.9	372.0	404.0	872.0	234.0	105.0	300.0	147.0	2441
	80ZA-1	0.14	4.170	<1.0	<1.0	<1.0	1.8	2.2	1.5	71.4	152.0	121.0	350
	80ZA-2	1.55	2.540	4.0	<1.0	7.6	18.8	12.8	3.9	11.6	294.0	167.0	520
	80ZA-3	0.19	0.046	<1.0	<1.0	17.8	16.1	11.0	68.6	13.2	347.0	245.0	719
Control Cell	80ZB-1	2.93	<0.001	<1.0	<1.0	1.2	9.8	11.4	17.9	162.0	205.0	220.0	627
	80ZB-2	4.64	0.036	<1.0	<1.0	15.2	73.6	129.0	65.9	196.0	408.0	303.0	1191
	80ZB-3	0.06	3.980	<1.0	<1.0	1.1	20.1	13.0	36.6	7.1	360.0	222.0	660
	80ZC-1	2.71	0.004	<1.0	10.8	<1.0	1.0	1.3	1.0	1.9	3.0	2.8	22
	80ZC-2	4.81	<0.001	<1.0	5.7	63.4	400.0	708.0	350.0	326.0	667.0	414.0	2934
	80ZC-3	2.28	<0.001	<1.0	1.0	10.5	66.8	99.5	90.6	341.0	379.0	430.0	1418
	80ZE-1	0.14	<0.001	<1.0	<1.0	<1.0	1.0	1.0	<1.0	51.8	14.2	56.2	124
	80ZE-2	0.43	<0.001	<1.0	<1.0	8.9	39.5	48.3	59.7	143.0	143.0	90.6	533
	80ZE-3	1.73	<0.001	<1.0	1.1	3.0	20.1	33.8	25.1	194.0	332.0	188.0	797
	80ZF-1	0.01	0.001	<1.0	<1.0	<1.0	1.3	3.3	<1.0	<1.0	1.3	1.0	7
	80ZF-2	1.35	<0.001	<1.0	<1.0	3.0	13.0	18.3	17.7	200.0	127.0	171.0	550
	80ZF-3	0.50	<0.001	<1.0	<1.0	1.9	23.3	25.2	17.2	226.0	284.0	274.0	852
Source Area	80ZG-1	5.23	<0.001	1.8	2.4	201.0	348.0	799.0	20.6	197.0	385.0	303.0	2258
	80ZG-2	9.26	<0.001	5.6	17.7	1220.0	1500.0	3640.0	5.5	240.0	790.0	321.0	7740
	80ZG-3	11.90	<0.001	7.2	9.9	880.0	1070.0	2590.0	3.8	161.0	463.0	253.0	5438

TABLE 15. AVERAGE AQUEOUS BTEXTMB CONCENTRATIONS IN PILOT CELLS
BEFORE AND AFTER FOUR MONTHS OF TREATMENT

Parameter	Treatment Cell	Screened Interval (ft from ground surface)	Mean BTEXTMB (µg/L)	Std. Dev. (µg/L)	Coefficient of Variation	Average Removal (%)
3/93 Data Before Treatment	Nitrate Cell	3.5-5.0	1810	2300	1.27	-
		6.5-8.0	1750	629	0.36	-
		9.5-11.0	1730	2230	1.29	-
	Control Cell	3.5-5.0	962	803	0.84	-
		6.5-8.0	5440	2970	0.55	-
		9.5-11.0	6730	11600	1.73	-
8/94 Data After Treatment	Nitrate Cell	3.5-5.0	207	181	0.87	89
		6.5-8.0	1960	3260	1.66	-12
		9.5-11.0	1300	1090	0.83	25
	Control Cell	3.5-5.0	195	293	1.50	80
		6.5-8.0	1300	1130	0.87	76
		9.5-11.0	932	334	0.36	86

below the zone of residual contamination, since it was not as apparent at 6.5-8.0 feet below grade as it was at 9.5-11 feet below grade. Therefore, the effect on residual saturation was presumably minimal. However, it could have influenced aqueous BTEXTMB concentrations at the lower level in this portion of the site. In fact, the uncharacteristically low mass ratio of mesitylene at this location in the Control Cell was probably due to denitrifying processes.

4. Core Analyses

As with the initial site characterization, core samples were again taken during the Interim Performance Evaluation to: (1) determine vertical and spatial extent of contamination, (2) evaluate the soil nutrient status, (3) characterize the microbial populations, and (4) evaluate the change in sediment toxicity. The latter two tasks were carried out by personnel at Rice University and Oklahoma State University, respectively, and have been reported elsewhere (Thomas et al, 1995; Bantle et al, 1996). The following section focuses on the changes in contaminant distribution and nutrient status brought about by operation of the pilot demonstration project.

a. Contaminant Distribution

Locations of the mid-test core samples have been presented in Figure 32, with the pre-test core sample locations also included for reference. It had been decided to locate the mid-test cores far enough away from the pre-test cores to avoid sampling the same location twice, as well as to avoid sampling an area adjacent to the pre-test core location which might have been disturbed by the initial core sampling. This turned out to be a mistake, because we had underestimated the magnitude of site heterogeneity. As a consequence, contaminant concentrations did not decrease in a consistent pattern downgradient of the source area, and the location of the mid-test core samples provided data which indicated that contaminant concentrations were either stable or increasing across the site. The data have been archived in Appendix A, and cumulative mass contours were generated from these data in a manner analogous to those used in the initial site characterization. To facilitate interpretation of the data, these contours will be discussed in Section IVD along with those of the Final Performance Evaluation.

Based on this evaluation of the core data, the effects of nitrate based bioremediation had thus far been minimal. The deeper core samples in Location 80ZA did substantiate the preferential removal of mesitylene over 1,2,3-trimethylbenzene which was observed in the geoprobe water samples as described previously. However, the total concentrations of BTEXTMB had not declined in the Nitrate Cell relative to the Control Cell. Although this was in part due to the heterogeneity of the site, there were no substantive changes in ratios of BTEXTMB to JP-4, indicating that these compounds were not being preferentially degraded in comparison to other fuel constituents (data not shown). A similar analysis of labile constituents (toluene,

ethylbenzene, and *m*-xylene) also showed no net effect (data not shown). Again, part of the problem may lie in site heterogeneity; some core locations showed "wetting fronts", ie, clear breaks in the core profiles where BTEXTMB ratios increase sharply with depth, whereas others showed no such increase (Appendix A). This probably indicates preferential flow paths or age-related differences in the specific origin of the contaminants within those layers. Regardless of the exact cause, the net effect of averaging the data obscures any changes that occur locally within the core profile.

b. Nutrient Status

Locations 80W, 80X, 80Z, and 80ZA (Figure 32) were sampled using the anaerobic glovebox as described previously to provide core material at three different depths for evaluating the soil nutrient status as well as for microbial characterization. These core groups were taken in the Nitrate Cell at different locations from those in the initial site characterization. In addition, Locations 80JC and 80KC, downgradient of the Nitrate Cell and the Control Cell, respectively, were taken adjacent to Locations 80JB and 80KB sampled in the initial site characterization. Data are shown for the soil chemical analyses in Table 16. In general, operation of the pilot system resulted in increased pH, nitrate, ammonia-nitrogen, and orthophosphate levels throughout the Nitrate Cell. Total Kjeldahl nitrogen and total phosphate levels generally decreased. This probably results from the combined effects of nitrate assimilation and decomposition, denitrification, and leaching of minerals. Other parameters (TOC, BTEXTMB, JP-4) were too variable in concentrations to generalize. Operation of the pilot demonstration project also resulted in slightly higher cell counts, as determined by phospholipid fatty acids (Table 16). Similarly, researchers at Rice University found that the total number of denitrifiers increased by an order of magnitude in most of the samples from the Nitrate Cell, and total numbers of aerobic heterotrophs and JP-4-degrading microorganisms also increased (Thomas et al, 1995). In summary, these data indicate that the microbial activity at the site has been increased as a result of pilot operation. This is in contrast to the contaminant distribution data, which generally showed no beneficial effect at this time.

D. FINAL PERFORMANCE EVALUATION

1. General System Performance

The lysimeter data from the Interim Performance Evaluation had shown that most of the applied nitrate was being transported to below the root zone in some cases, but that there was substantial variability across the site, making it difficult to estimate the total mass of nitrate being delivered to the contaminated zone. To address this problem, it was decided that part of each test cell should be stripped of the vegetative cover to facilitate nitrate transport in the Nitrate Cell and provide a corresponding control in the Control Cell. The pilot system was shut down Nov 11, and

TABLE 16. CHEMICAL ANALYSES OF EGLIN AFB CORES, COLLECTED 8/94, DURING INTERIM PERFORMANCE EVALUATION

Core Sample*	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bot int (ft MSL)	Int (ft)	pH (pH units)	NH ₄ -N (mg/kg)	NO ₃ /NO ₂ -N (mg/kg)	TKN (mg/kg)	o-PO ₄ -P (mg/kg)	tot-PO ₄ -P (mg/kg)	TOC (mg/kg)	BTEXTMB (mg/kg)	JP-4 (mg/kg)	PLFA (nM/g)
80W2	2.3	3.4	9.7	8.6	1.1	7.11	2.5	0.9	73.8	6.44	87.2	0.274	0.008	10	8.27
80W1	3.4	4.5	8.6	7.5	1.1	7.24	2.0	0.8	8.2	5.08	8.0	0.059	0.064	1310	7.36
80W4	4.8	5.9	7.2	6.1	1.1	7.16	2.1	0.9	52.0	6.92	68.0	0.063	0.074	<10	2.35
80X2	2.5	3.8	10.3	9.0	1.3	7.44	2.4	0.9	148.0	0.58	26.2	0.188	70.800	4560	5.87
80X1	3.8	5.0	9.0	7.8	1.2	7.17	1.8	0.9	95.2	<0.5	27.6	0.128	18.900	2620	4.29
80X4	5.3	6.4	7.5	6.4	1.1	7.69	1.9	0.8	72.4	1.49	21.6	0.098	217.000	5780	2.89
80Z2	1.3	2.4	9.7	8.6	1.1	6.90	2.8	0.9	53.6	1.47	26.0	0.113	0.035	<10	3.81
80Z1	2.4	3.5	8.6	7.5	1.1	6.80	4.4	0.9	26.6	1.28	15.4	0.178	21.500	3750	8.56
80Z4	4.9	6.0	6.1	5.0	1.1	7.02	2.7	0.8	15.2	0.90	26.6	0.032	2.010	34	1.03
80ZA2	2.3	3.4	9.5	8.4	1.1	7.03	2.5	1.4	142.0	4.68	295.0	0.066	0.023	138	6.58
80ZA1	3.4	4.5	8.4	7.3	1.1	7.06	2.5	0.8	66.0	3.31	44.2	0.047	16.900	2630	8.35
80ZA4	4.8	5.9	7.0	5.9	1.1	7.26	1.5	1.2	73.2	1.01	123.0	0.008	0.711	55	1.70
80JC2	2.3	3.4	7.8	6.7	1.1	6.56	4.0	0.8	54.6	1.16	31.6	0.091	0.876	11	1.63
80JC1	3.4	4.5	6.7	5.6	1.1	6.55	4.1	0.8	37.4	1.33	21.4	0.062	0.188	<10	2.02
80JC3	5.9	7.0	4.2	3.1	1.1	6.77	4.0	0.9	27.2	2.03	14.6	0.020	0.010	<10	0.77
80KC2	5.0	6.0	7.5	6.5	1.0	6.51	1.7	0.8	8.4	<0.5	3.4	0.011	<0.001	<10	0.10
80KC1	6.0	7.5	6.5	5.0	1.5	6.83	1.8	0.8	2.4	<0.5	7.0	0.005	<0.001	<10	0.19
80KC4	7.8	8.9	4.7	3.6	1.1	6.69	1.8	0.8	1.8	<0.5	2.4	0.004	0.308	<10	0.51

* Core Locations 80W, 80X, 80Z, and 80ZA were inside the Nitrate Cell. Locations 80JC and 80KC were downgradient and upgradient, respectively.

sod removal commenced Nov 15. A sod cutter was used to cut the roots 3 inches below ground surface, and the sod was removed manually. Two 31.5-foot x 31.5-foot areas were cleared, one in each test cell (Figure 33). The cleared area represented 10% of the total treatment area. The ground surface was then raked, cleared, and overlain with a black permeable plastic fiber designed to prevent weed growth but allow water transport (Dewitt Pro 5 Weed Barrier). The pilot system was restarted Nov 18, and operation was continued through the winter and spring of the following year. There were no observed problems with these stripped plots, which remained essentially vegetation-free for the duration of the study, and the applied recharge permeated quickly and did not pond on the surface. There were few operational problems for the pilot demonstration system in general, except for difficulties encountered in maintaining adequate nitrate concentrations in the stock tank due to the slow dissolution rate of the nitrate salt during the colder months. Because of decreased rainfall, water table elevations were more steady during this time, until about Apr 95 (Figure 17). The Final Performance Evaluation was conducted May 13-30, 1995, after approximately 1 year of continuous operation, and the pilot study was then discontinued.

2. Lysimeter Samples

Lysimeters were again installed during the Final Performance Evaluation to provide additional information on transport of nitrogen and carbon through the rhizosphere. Immediately after turning off the sprinklers, five PVC lysimeters were installed 1.5 feet below ground surface in the Nitrate Cell. Vacuums were applied and water was sampled 1 to 2 hours later using a peristaltic pump. Samples were taken for nitrate, nitrite, ammonia, sulfate, and TOC. The lysimeters were then extracted, cleaned, and the procedure was repeated for three more sets in the Nitrate Cell to provide 20 locations total, with one set being located within the stripped plot and the other sets located outside of the stripped plots (Figure 33). Higher concentrations of nitrate were generally found in water beneath the stripped plot compared to other areas of the cell and, correspondingly, this ground water was also generally lower in TOC (Figure 34). These data provide good evidence that operation of the pilot cells without removal of vegetation did not allow adequate transfer of electron acceptor to the subsurface at this time. However, it is still unknown whether the nitrate sink was due to decay of vegetative growth providing high levels of organic carbon that may be preferentially used for denitrification or to nitrate-nitrogen assimilation by the vegetation. Nitrite-nitrogen and ammonia-nitrogen were generally less than 0.5 mg/L and 1 mg/L, respectively, and there was no significant correlation between either of these and nitrate concentrations (data not shown). These data do show a high rate of nitrate transport beneath the stripped plot, in an area of the Nitrate Cell which is more highly contaminated (Figure 5). It should also be noted that the increased nitrate utilization outside of the stripped plot area may only be representative of the system performance in the spring, and that operation during the fall and winter may not have resulted in such high nitrate losses.

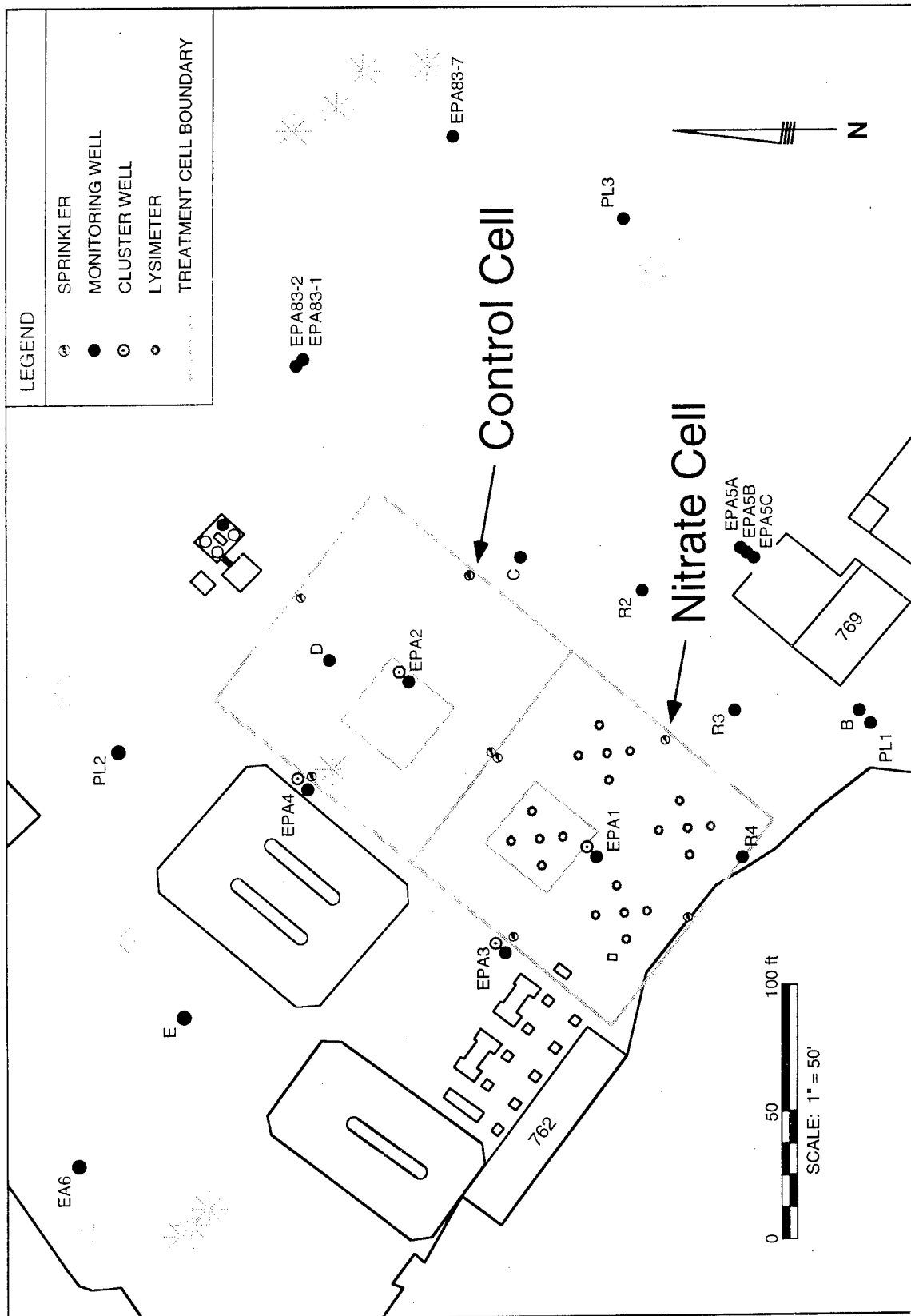
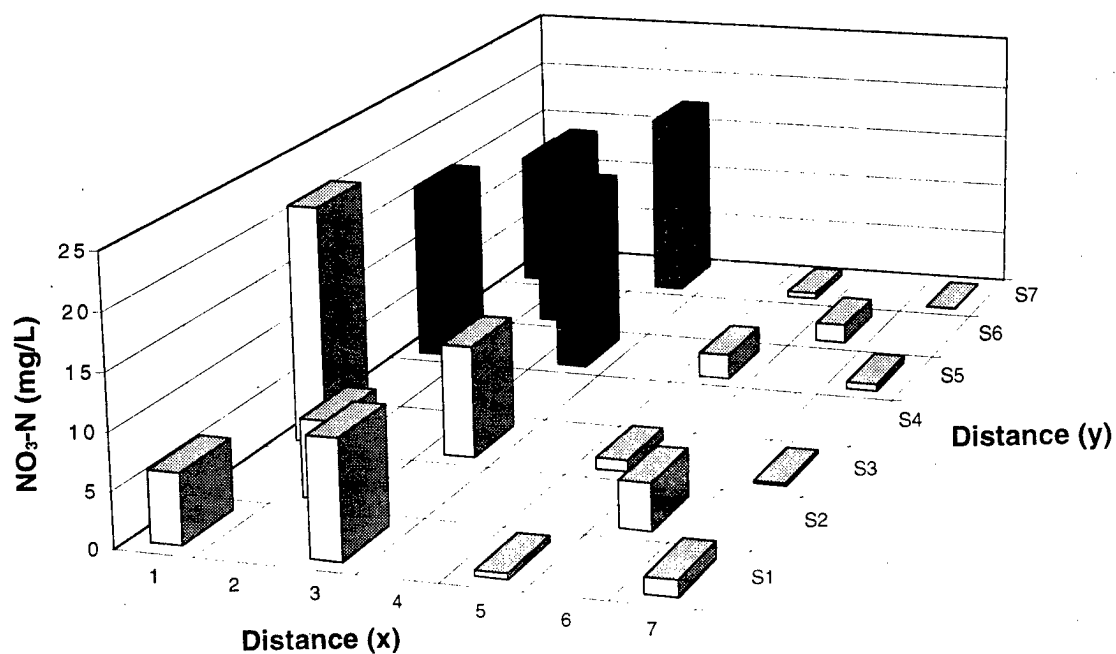


Figure 33. Location of Stripped Plots (Shaded Areas) Which Were Constructed Nov 94. Also Shown are Locations of Lysimeters Which Were Installed in the Nitrate Cell During the Final Performance Evaluation.

a) Nitrate-Nitrogen in Lysimeter Samples



b) Total Organic Carbon in Lysimeter Samples

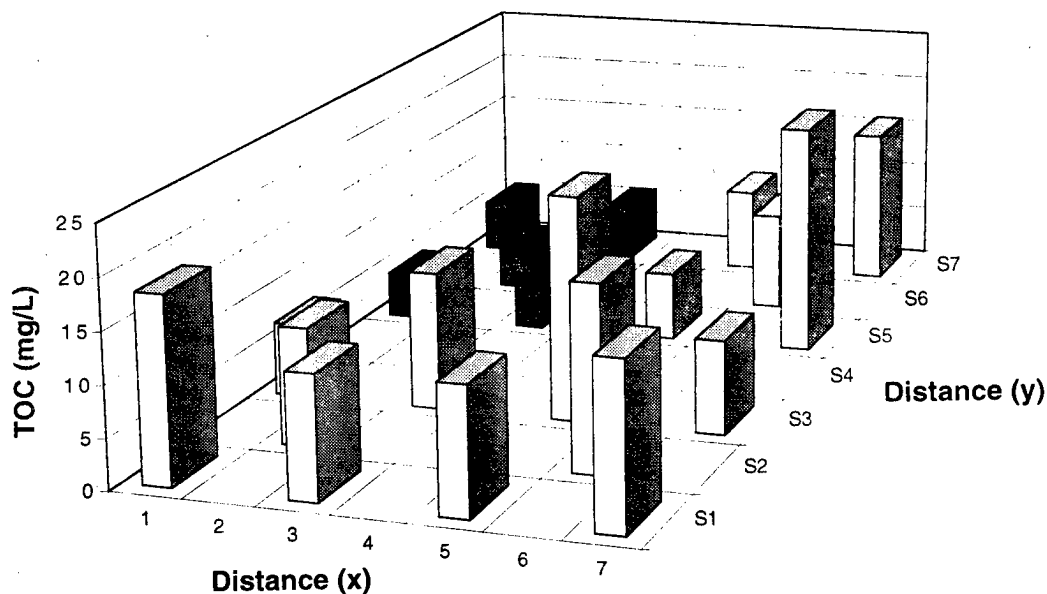


Figure 34. Concentrations of a) Nitrate-Nitrogen and b) Total Organic Carbon in Nitrate Cell Lysimeters. Shaded Bars Represent Concentrations Beneath Stripped Plot.

3. Ground Water Samples

As with the previous Performance Evaluation, ground water samples were again taken from all of the area wells and from several locations at three depths using the geoprobe. The well data have been shown in Table 2, and the geoprobe data are shown in Table 17. The geoprobe locations correspond to the post-test core locations, and are shown in Figure 35. The POL well data are too variable to generalize, but there are some trends that are apparent. First, there again does not appear to be any significant contamination of the downgradient wells with nitrate or its degradation products. With the exception of R4, there was no detectable nitrate, nitrite, or nitrous oxide in any of the POL wells during the Final Performance Evaluation (Table 2). Second, BTEXTMB levels generally decreased relative to those observed during the Interim Performance Evaluation, with the exception of EPA1, located in the center of the Nitrate Cell. The reason for this is unknown, but it is probably an artifact, since all of the data prior to this sampling point showed no BTEXTMB in this well for several months (Figure 25a). Other exceptions were observed for the deeper PL wells, indicating that some of the BTEXTMB was mobilized to these deeper regions. It is of interest to note that this increase was much less in PL1, downgradient of the Nitrate Cell, than in PL2 and PL3, downgradient of the Control Cell (Table 2). Finally, the ratio of mesitylene to 1,2,3-trimethylbenzene was approximately 1:2 in the Nitrate Cell wells (EPA1, R4) and approximately 3:1 in the Control Cell wells (EPA2, D).

This again indicates that biodegradation is active in either one or both of these treatment cells. This trend is more evident in the geoprobe samples (Table 17). In the Nitrate Cell, most of the mesitylene to 1,2,3-trimethylbenzene ratios are below one in the Nitrate Cell, whereas the ratios increase to greater than one in the Control Cell. A notable exception is observed at Location 80ZT in the Control Cell, which has a MESIT:TMB ratio of much less than one in the lower level sampled with the geoprobe (Table 17). As with the Interim Performance Evaluation, these data also indicate some crossover of Nitrate Cell recharge into the Control Cell at the lower level, since nitrite and nitrous oxide concentrations were higher here than anywhere else in the Control Cell (Table 17). Another trend of interest is that areas that are heavily contaminated within the Nitrate Cell are also depleted of electron acceptors. For example nitrate, nitrite, and sulfate concentrations are all generally much lower at Locations 80ZM and 80ZO, which typically had higher aqueous BTEXTMB concentrations. Location 80ZM was adjacent to the stripped plot (Figure 35), and therefore presumably had received high concentrations of nitrate which had been transported to at least 1.5 feet below ground surface (Figures 33, 34). It is reasonable to expect that most of the applied electron acceptors were utilized within the contaminated intervals at this location. There was corresponding evidence of biodegradation under sulfate-reducing conditions in the Control Cell, as shown by much lower sulfate concentrations (except where BTEXTMB was low or absent) and higher thiosulfate concentrations than in the Nitrate Cell (Table 17). Again, these data support the conclusion that bioremediation was occurring in both cells.

TABLE 17. GEOPROBE WATER QUALITY DATA FOR EGLIN AFB SITE DURING FINAL PERFORMANCE EVALUATION, 5/95

Area	Sample	Grade Elev. (ft MSL)	Bot. Screen (ft from GS)	Top Screen (ft from GS)	Bot. Screen (ft MSL)	Top Screen (ft MSL)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S ₂ O ₃ (mg/L)	TOC (mg/L)	CH ₄ (mg/L)	N ₂ O (mg/L)
Uncontaminated Control	80KD-1	12.51	5.00	3.50	7.51	9.01	5.44	3.1	NA	0.8	2.1	0.15	<0.05	0.17	<0.05	3.37	<0.5	2.6	<0.01	<0.001
	80KD-2	12.51	8.00	6.50	4.51	6.01	6.40	0.7	NA	0.8	3.7	0.12	<0.05	0.25	<0.05	1.21	0.58	5.3	0.66	<0.001
	80KD-3	12.51	11.00	9.50	1.51	3.01	6.37	0.6	NA	1.1	8.4	0.11	<0.05	0.52	<0.05	<0.5	<0.5	2.7	2.09	<0.001
Nitrate Cell	80ZK-1	11.86	5.00	3.50	6.86	8.36	6.86	0.8	NA	<0.5	9.8	2.43	0.27	1.11	0.69	6.47	<0.5	8.0	0.24	0.127
	80ZK-2	11.86	8.00	6.50	3.86	5.36	7.07	0.8	NA	<0.5	9.2	3.82	1.22	0.11	0.69	8.99	<0.5	9.1	0.59	1.120
	80ZK-3	11.86	11.00	9.50	0.86	2.36	6.79	0.7	NA	<0.5	10.0	4.14	0.09	2.03	1.55	9.51	<0.5	11.6	0.41	0.544
	80ZM-1	12.42	5.50	4.00	6.92	8.42	7.19	0.7	NA	<0.5	10.0	0.11	<0.05	2.29	<0.05	<0.5	<0.5	12.5	6.94	<0.001
	80ZM-2	12.42	8.00	6.50	4.42	5.92	6.84	0.7	NA	<0.5	9.6	0.10	<0.05	1.99	0.08	<0.5	<0.5	12.2	11.10	<0.001
	80ZM-3	12.42	11.00	9.50	1.42	2.92	7.07	0.7	NA	<0.5	8.1	0.10	<0.05	2.42	0.07	<0.5	<0.5	10.5	11.30	<0.001
	80ZN-1	11.03	5.00	3.50	6.03	7.53	6.54	0.6	NA	<0.5	10.3	0.13	<0.05	1.31	0.41	3.00	<0.5	7.2	0.15	0.002
	80ZN-2	11.03	8.00	6.50	3.03	4.53	6.72	0.6	NA	<0.5	8.6	0.10	<0.05	0.91	0.77	7.70	<0.5	5.6	0.11	0.120
	80ZN-3	11.03	11.00	9.50	0.03	1.53	6.76	0.8	NA	<0.5	8.7	0.10	<0.05	0.59	0.52	8.43	<0.5	4.8	0.16	0.129
	80ZO-1	11.03	5.00	3.50	6.03	7.53	6.69	0.9	NA	<0.5	9.6	<0.05	<0.05	1.83	0.56	<0.5	0.61	4.7	2.94	<0.001
	80ZO-2	11.03	8.00	6.50	3.03	4.53	6.45	1.2	NA	<0.5	9.2	0.61	<0.05	3.68	0.26	1.60	<0.5	21.8	2.36	<0.001
	80ZO-3	11.03	11.00	9.50	0.03	1.53	6.86	0.7	NA	<0.5	8.6	0.61	<0.05	1.64	0.55	1.62	<0.5	7.0	0.25	<0.001
Control Cell	80ZS-1	11.98	5.00	3.50	6.98	8.48	7.08	0.9	NA	1.0	10.4	1.23	0.11	0.70	0.63	6.38	<0.5	4.5	0.10	0.010
	80ZS-2	11.98	8.00	6.50	3.98	5.48	7.16	0.7	NA	0.7	10.5	<0.05	0.72	0.97	0.47	7.49	<0.5	6.3	0.48	5.850
	80ZS-3	11.98	11.00	9.50	0.98	2.48	7.02	0.7	NA	<0.5	10.3	7.56	2.40	0.56	0.32	10.50	<0.5	9.7	<0.01	6.960
	80ZT-1	12.44	5.00	3.50	7.44	8.94	6.57	0.8	NA	<0.5	10.5	0.11	<0.05	1.29	0.21	0.51	0.76	11.9	1.59	<0.001
	80ZT-2	12.44	8.00	6.50	4.44	5.94	6.90	0.5	NA	<0.5	11.2	0.10	<0.05	1.04	0.08	<0.5	1.51	5.5	0.58	<0.001
	80ZT-3	12.44	11.00	9.50	1.44	2.94	7.21	NA	NA	<0.5	9.5	0.11	2.08	1.24	0.50	9.61	<0.5	5.0	0.41	9.200
	80ZX-1	13.81	5.50	4.00	8.31	9.81	6.57	1.4	NA	0.9	10.6	0.10	<0.05	0.31	<0.05	0.90	<0.5	4.5	1.37	<0.001
	80ZX-2	13.81	8.00	6.50	5.81	7.31	6.66	0.8	NA	0.6	10.6	0.10	<0.05	0.14	<0.05	<0.5	1.30	2.7	0.11	<0.001
	80ZX-3	13.81	11.00	9.50	2.81	4.31	6.70	0.7	NA	<0.5	10.4	0.10	<0.05	0.09	<0.05	1.41	1.34	2.1	0.60	<0.001
	80ZY-1	13.81	5.50	4.00	8.31	9.81	6.78	1.7	NA	<0.5	9.0	<0.05	<0.05	0.32	<0.05	0.61	1.25	7.8	1.00	<0.001
	80ZY-2	13.81	8.00	6.50	5.81	7.31	6.89	0.9	NA	<0.5	10.9	<0.05	<0.05	0.14	<0.05	<0.5	2.49	2.8	0.75	<0.001
	80ZY-3	13.81	11.00	9.50	2.81	4.31	6.97	0.6	NA	0.6	11.2	0.10	<0.05	0.21	0.15	0.55	2.05	5.9	0.82	<0.001
Source Area	80ZZ-1	12.22	5.00	3.50	7.22	8.72	6.91	1.0	NA	1.5	10.5	<0.05	<0.05	0.53	<0.05	2.11	0.96	3.0	0.35	<0.001
	80ZZ-2	12.22	8.00	6.50	4.22	5.72	7.00	0.6	NA	<0.5	9.5	<0.05	<0.05	0.27	0.13	<0.5	1.45	2.4	0.40	<0.001
	80ZZ-3	12.22	11.00	9.50	1.22	2.72	6.92	0.7	NA	<0.5	10.3	0.10	<0.05	0.29	0.22	<0.5	1.00	3.7	0.55	<0.001
	80ZZA-1	12.74	5.00	3.50	7.74	9.24	6.95	1.9	NA	<0.5	7.4	0.53	<0.05	0.10	<0.05	9.20	<0.5	1.0	<0.01	<0.001
	80ZZA-2	12.74	8.00	6.50	4.74	6.24	6.81	0.5	NA	1.4	11.6	0.12	<0.05	0.25	<0.05	1.24	1.41	3.2	0.37	<0.001
	80ZZA-3	12.74	11.00	9.50	1.74	3.24	6.77	0.5	NA	1.5	8.3	0.10	<0.05	0.13	0.15	<0.5	1.69	3.8	2.38	<0.001
	80ZL-1	13.20	5.50	4.00	7.70	9.20	6.39	0.5	NA	1.7	2.4	0.10	<0.05	2.79	<0.05	<0.5	<0.5	34.1	2.29	<0.001
	80ZL-2	13.20	8.00	6.50	5.20	6.70	6.41	0.6	NA	1.7	2.3	0.11	<0.05	2.81	<0.05	<0.5	<0.5	16.0	10.90	<0.001
	80ZL-3	13.20	11.00	9.50	2.20	3.70	6.19	0.5	NA	2.1	2.7	<0.05	<0.05	3.76	<0.05	<0.5	0.57	25.4	6.10	<0.001

TABLE 17 (cont). GEOPROBE WATER QUALITY DATA FOR EGLIN AFB SITE DURING FINAL PERFORMANCE EVALUATION, 5/95

Area	Sample	BZ (µg/L)	TOL (µg/L)	ETBZ (µg/L)	PXYL (µg/L)	MAXYL (µg/L)	OXYL (µg/L)	MESIT (µg/L)	PSCU (µg/L)	TMB (µg/L)	BIEXTMB (µg/L)
Uncontaminated Control	80KD-1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
	80KD-2	<1.0	118.0	198.0	340.0	642.0	362.0	57.9	189.0	67.8	1975
	80KD-3	<1.0	7.1	147.0	279.0	418.0	179.0	226.0	465.0	242.0	1963
Nitrate Cell	80ZK-1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.4	2.9	1.5	6
	80ZK-2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.1	3.3	1.8	6
	80ZK-3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	1.4	46.6	49
	80ZM-1	<1.0	<1.0	52.5	69.8	126.0	1.8	153.0	532.0	153.0	1088
	80ZM-2	129.0	3.4	1130.0	646.0	2320.0	2.1	202.0	667.0	334.0	5434
	80ZM-3	53.1	8.6	853.0	862.0	1590.0	143.0	149.0	522.0	225.0	4406
	80ZN-1	4.5	2.5	6.7	11.4	10.6	3.7	13.9	100.0	31.9	185
	80ZN-2	6.6	<1.0	10.2	10.1	5.5	<1.0	3.3	10.4	5.8	52
	80ZN-3	<1.0	<1.0	4.1	4.2	3.4	<1.0	2.1	6.0	5.2	25
	80ZO-1	1.7	1.1	108.0	174.0	336.0	42.0	104.0	298.0	169.0	1234
	80ZO-2	13.4	<1.0	67.6	214.0	344.0	9.2	56.0	222.0	105.0	1031
	80ZO-3	2.1	<1.0	168.0	243.0	68.6	15.0	45.9	127.0	41.9	712
	80ZS-1	<1.0	<1.0	<1.0	<1.0	1.1	<1.0	9.0	8.2	4.3	23
	80ZS-2	3.2	<1.0	6.0	7.4	3.3	<1.0	4.9	18.6	9.2	53
	80ZS-3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	11.6	12.1	25
Control Cell	80ZT-1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	11.4	3.6	5.9	21
	80ZT-2	<1.0	<1.0	4.0	21.0	37.7	26.9	190.0	252.0	267.0	799
	80ZT-3	<1.0	<1.0	2.8	11.4	12.1	14.2	28.2	115.0	110.0	294
	80ZX-1	<1.0	<1.0	2.3	4.3	6.7	3.0	2.5	5.6	2.9	27
	80ZX-2	<1.0	<1.0	1.8	4.2	5.8	3.8	199.0	123.0	102.0	440
	80ZX-3	<1.0	<1.0	4.6	24.1	15.0	30.0	137.0	69.1	68.6	348
	80ZY-1	<1.0	<1.0	5.1	9.7	18.2	2.3	114.0	81.1	103.0	333
	80ZY-2	<1.0	<1.0	5.5	16.6	30.8	<1.0	54.7	45.7	36.0	189
	80ZY-3	<1.0	<1.0	<1.0	1.4	2.6	<1.0	33.0	18.3	25.7	81
	80ZZ-1	<1.0	<1.0	1.3	2.7	3.6	2.1	5.1	4.9	3.8	24
	80ZZ-2	<1.0	<1.0	2.9	5.9	11.3	2.1	140.0	33.6	53.7	250
	80ZZ-3	<1.0	<1.0	1.0	2.0	1.8	<1.0	70.5	41.4	15.1	132
	80ZZA-1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
	80ZZA-2	<1.0	<1.0	<1.0	4.5	2.0	7.7	218.0	118.0	246.0	596
	80ZZA-3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	49.0	8.4	21.4	79
Source Area	80ZL-1	<1.0	1.5	58.3	95.4	209.0	20.9	180.0	217.0	231.0	1013
	80ZL-2	<1.0	20.4	963.0	1290.0	2960.0	70.8	295.0	932.0	380.0	6911
	80ZL-3	3.3	10.0	1210.0	1400.0	3270.0	5.8	190.0	688.0	321.0	7098

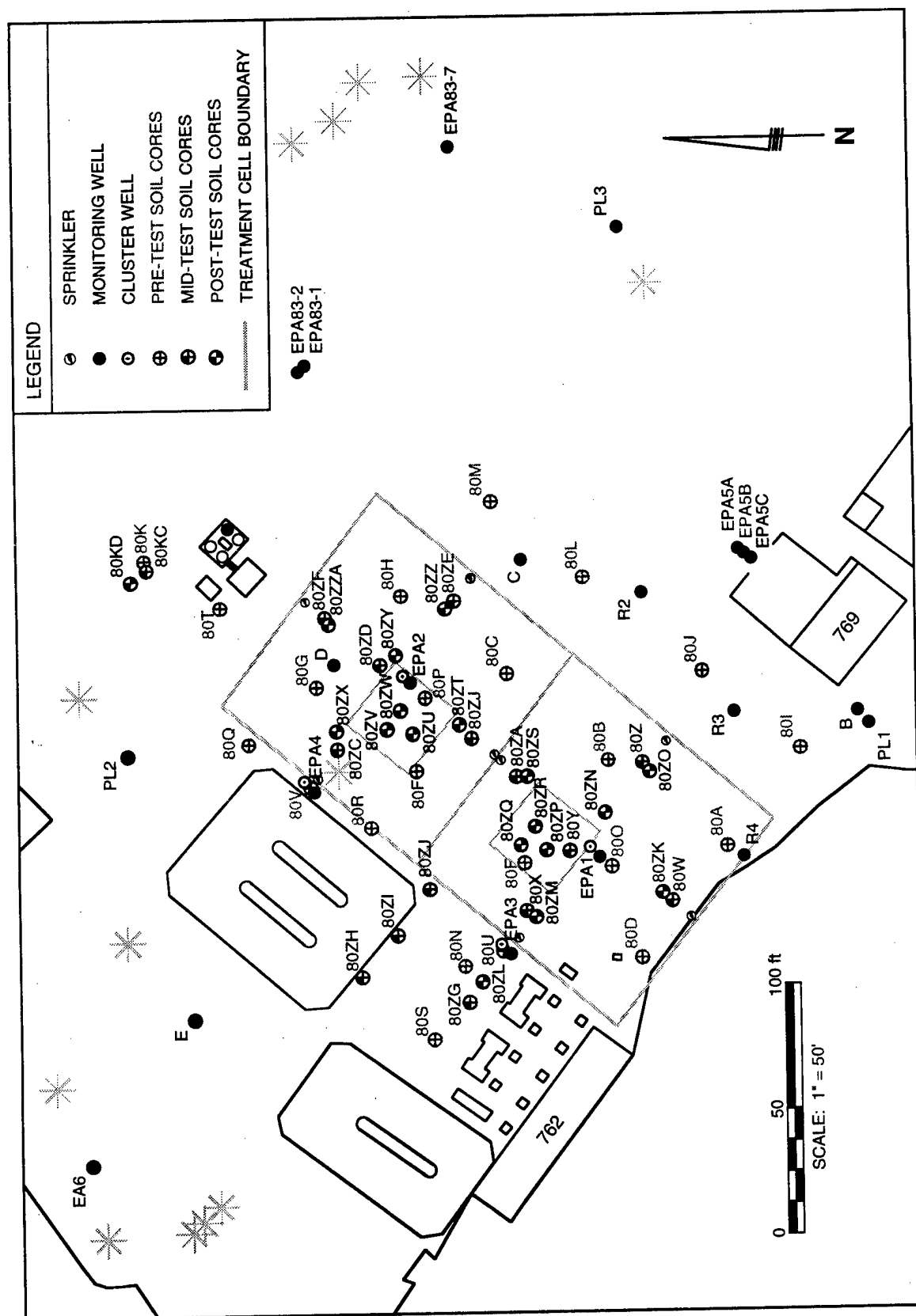


Figure 35. Location of Post-Test Core Samples, Taken During Final Performance Evaluation. Pre- and Mid-Test Core Sample Locations are Shown for Reference.

Summary data for BTEXTMB and electron acceptors in the cluster well averages for each treatment cell are shown in Figure 36. The data illustrate that, for most of the locations, the Interim Performance Evaluation was probably conducted too early to see significant reductions in contaminant levels, since aqueous BTEXTMB levels were still quite high and there was not yet any significant breakthrough of sulfate and/or nitrate/nitrite. Of interest is the increased breakthrough of nitrate/nitrite prior to sod removal in the Nitrate Cell, indicating that removal of sod was not solely responsible for enhanced transport of this electron acceptor. However, it may have contributed. Another contributing factor may have been the decreased grass growth during the winter months; active growth ceased from about mid-November to early March (Appendix B). There was increased sulfate breakthrough as well for all locations prior to sod removal, although the breakthrough was more complete at EPA1, in the center of the Nitrate Cell, than at EPA2, in the center of the Control Cell (Figure 36b, c). There was only limited breakthrough of either electron acceptor in the more contaminated region at EPA3, and this was probably due to the high concentrations of BTEXTMB which were still present (Figure 36c). These data do not show a direct benefit of sod removal in the stripped plots, but do illustrate the different microbial processes which were occurring in the separate treatment cells.

4. Core Analyses

As with the two previous site characterizations, core samples were obtained during the Final Performance Evaluation to: (1) evaluate the soil nutrient status, (2) determine vertical and spatial extent of contamination, (3) characterize the microbial populations, and (4) evaluate the change in sediment toxicity. Unlike the first two site characterizations, however, cores were obtained from locations adjacent to those in the Interim Performance Evaluation to minimize the effects of site heterogeneity and provide a better comparison of contaminant reduction (Figure 35). In addition, three locations within each of the stripped plots were sampled to determine whether removal of the vegetative cover enhanced bioremediation.

a. Nutrient Status

Locations 80ZK, 80ZM, 80ZO, and 80ZS (Figure 35) were sampled using the anaerobic glovebox as described previously to provide core material at three different depths for evaluating the soil nutrient status as well as for microbial characterization. These core groups were taken in the Nitrate Cell at adjacent locations to those for the Interim Performance Evaluation. In addition, Locations 80JD and 80KD, downgradient of the Nitrate Cell and the Control Cell, respectively, were taken adjacent to Locations 80JC and 80KC sampled in the Interim Performance Evaluation. Finally, Locations 80ZN and 80ZY, in the center of the Nitrate Cell and the Control Cell, respectively, were sampled at five depths each to compare the soil nutrient status between the two cells and provide core material for treatability studies. Data are shown for the soil chemical analyses in Table 18. Compared to the Interim

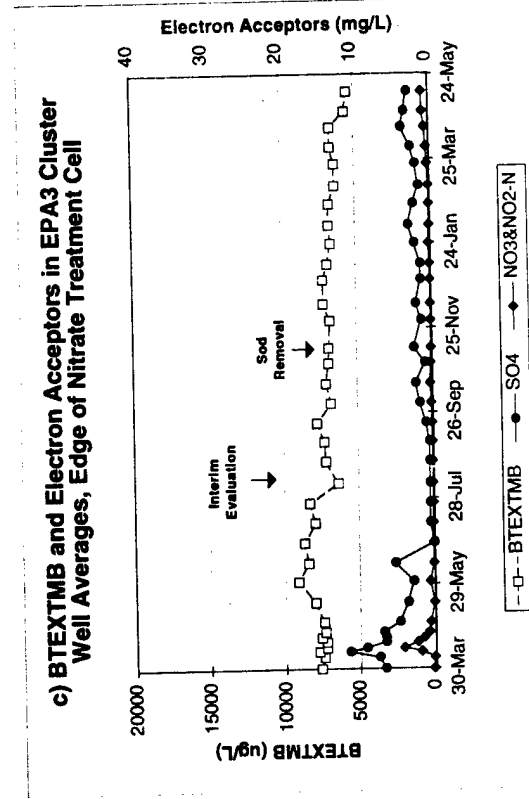
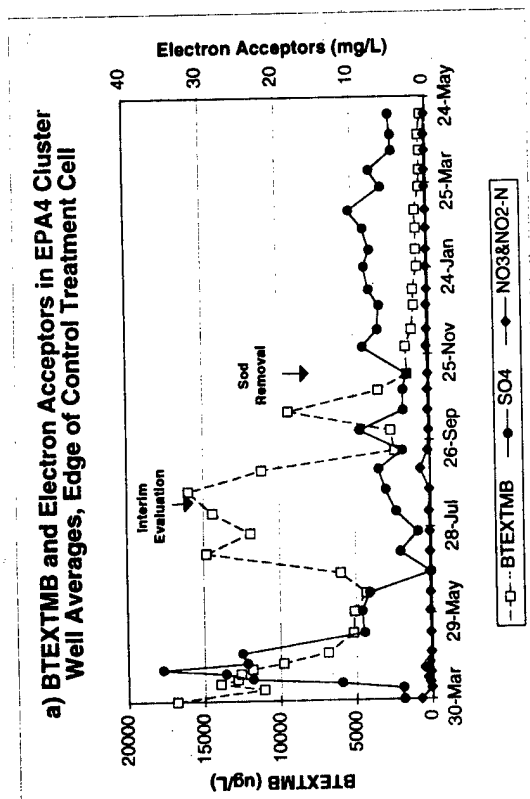
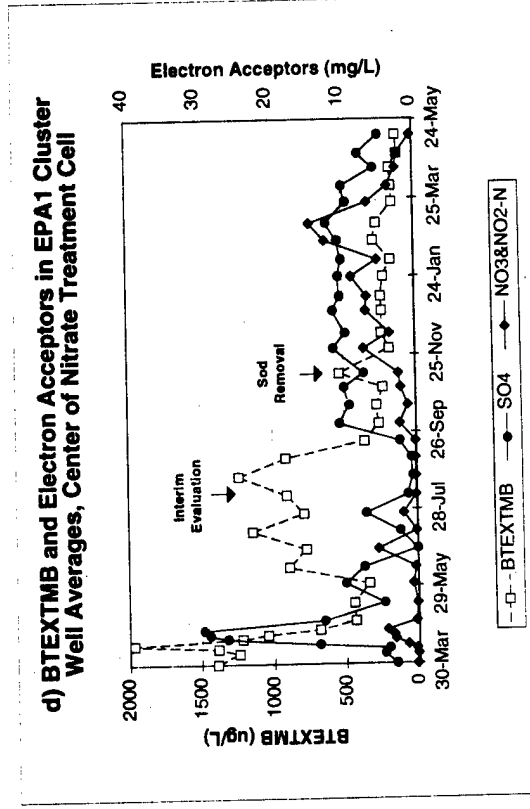
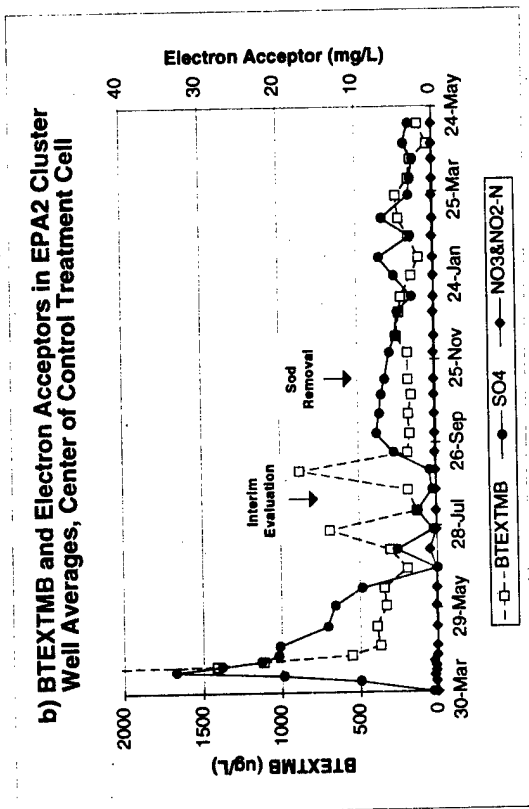


Figure 36. BTEXTMB and Electron Acceptor Levels in EPA Cluster Well Averages at a) Edge of Control Cell, b) Center of Control Cell, c) Edge of Nitrate Cell, and d) Center of Nitrate Cell

TABLE 18. CHEMICAL ANALYSES OF EGLIN AFB CORES, COLLECTED 5/95,
DURING FINAL PERFORMANCE EVALUATION

Core Sample*	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bot int (ft MSL)	Int (ft)	pH (pH units)	NH ₄ -N (mg/kg)	NO ₃ /NO ₂ -N (mg/kg)	TKN (mg/kg)	o-PO ₄ -P (mg/kg)	tot-PO ₄ -P (mg/kg)	TOC (mg/kg)	BTEXTMB (mg/kg)	JP-4 (mg/kg)	PLFA (nM/g)
80ZK2	2.1	3.2	9.8	8.7	1.1	7.55	2.0	1.8	198.0	1.80	276.0	0.146	<0.001	<10	1.29
80ZK1	3.2	4.3	8.7	7.6	1.1	7.85	1.0	<0.5	75.6	3.79	88.4	0.045	0.005	1080	3.58
80ZK3	5.7	6.8	6.2	5.1	1.1	8.14	1.3	<0.5	24.2	3.17	30.4	0.020	<0.001	<10	0.80
80ZM2	2.6	3.4	9.9	9.1	0.8	7.70	2.7	<0.5	177.0	<0.5	27.8	0.135	13.500	2760	4.02
80ZM1	3.4	4.5	9.1	8.0	1.1	8.07	1.8	<0.5	80.8	0.80	24.0	0.062	25.300	3920	2.31
80ZM4	5.1	5.9	7.4	6.6	0.8	8.25	1.2	<0.5	82.0	0.57	17.4	0.082	582.000	14900	1.74
80ZO2	1.1	2.2	9.9	8.8	1.1	7.55	1.1	1.0	263.0	0.51	56.8	0.223	<0.001	<10	0.57
80ZO1	2.2	3.3	8.8	7.7	1.1	7.46	2.1	<0.5	248.0	0.60	30.8	0.258	5.830	2160	0.77
80ZO3	4.7	5.8	6.3	5.2	1.1	8.01	1.4	<0.5	47.0	1.52	28.4	0.029	0.169	<10	0.76
80ZS2	2.3	3.3	9.5	8.5	1.0	7.65	1.0	1.5	71.4	2.32	82.6	0.096	<0.001	<10	0.90
80ZS1	3.3	4.3	8.5	7.5	1.0	7.89	0.9	0.9	63.4	1.29	41.8	0.048	0.434	1820	2.81
80ZS4	4.6	5.7	7.2	6.1	1.1	8.20	0.9	<0.5	18.8	0.94	12.4	0.026	<0.001	18	1.58
80JD1	2.5	3.6	7.7	6.6	1.1	7.44	1.8	<0.5	104.0	1.29	41.0	0.130	6.970	47	1.24
80JD4	4.8	5.9	5.4	4.3	1.1	7.43	0.9	<0.5	39.6	0.59	19.4	0.033	0.855	<10	0.96
80JD3	5.9	6.9	4.3	3.3	1.0	8.07	0.9	<0.5	22.2	1.07	20.6	0.024	<0.001	<10	0.66
80KD1	3.7	4.8	9.0	7.9	1.1	6.32	1.0	<0.5	21.2	<0.5	16.5	0.021	0.046	<10	0.24
80KD4	5.1	6.2	7.6	6.5	1.1	6.53	0.8	<0.5	5.2	<0.5	4.6	0.006	<0.001	<10	0.69
80KD3	6.2	7.3	6.5	5.4	1.1	7.63	1.8	<0.5	2.6	<0.5	3.4	0.006	<0.001	<10	0.19
80KD6	7.6	8.7	5.1	4.0	1.1	8.60	0.7	<0.5	0.6	<0.5	3.2	0.007	0.016	<10	0.28
80ZN2	1.6	2.7	9.9	8.8	1.1	7.47	1.1	1.2	240.0	2.89	211.0	0.281	<0.001	<10	0.60
80ZN1	2.7	3.8	8.8	7.7	1.1	7.51	1.5	0.8	98.6	2.25	88.4	0.374	0.247	1250	0.47
80ZN4	4.1	5.2	7.4	6.3	1.1	8.06	1.0	<0.5	38.0	1.69	23.0	0.058	0.752	108	1.10
80ZN3	5.2	6.3	6.3	5.2	1.1	8.12	1.7	<0.5	68.4	3.95	40.0	0.058	0.195	15	1.07
80ZN5	6.9	8.0	4.6	3.5	1.1	8.36	1.1	<0.5	15.6	1.54	13.6	0.035	0.017	<10	0.58
80ZY2	1.6	2.7	11.1	10.0	1.1	7.51	1.0	<0.5	85.6	<0.5	28.8	0.115	0.209	<10	0.84
80ZY1	2.7	3.8	10.0	8.9	1.1	7.66	0.9	<0.5	66.6	<0.5	30.2	0.065	0.045	<10	0.64
80ZY4	4.1	5.2	8.6	7.5	1.1	7.54	1.1	<0.5	140.0	<0.5	25.0	0.091	0.340	1540	NA
80ZY3	5.2	6.3	7.5	6.4	1.1	7.82	1.0	<0.5	42.0	<0.5	12.6	0.037	7.440	679	1.00
80ZY5	6.9	8.0	5.8	4.7	1.1	8.30	0.8	<0.5	13.0	<0.5	8.6	0.011	0.055	10	0.42

* Core Locations 80ZK, 80ZM, 80ZO, 80ZS, and 80ZN were in Nitrate Cell. Location 80ZY was in Control Cell. Locations 80JD and 80KD were downgradient and upgradient of Nitrate Cell, respectively.

Performance Evaluation data (Table 16), continued operation of the pilot system resulted in increased pH levels throughout the Nitrate Cell. Other parameters did not change appreciably, although there was a slight decline in nitrate- and ammonia-nitrogen throughout the Nitrate Cell (Table 18). Other parameters (TOC, BTEXTMB, JP-4) were again too variable in concentrations to generalize. There was little discernable difference in the soil chemistry between the two cells (80ZN vs 80ZY, Table 18) other than an increased level of total phosphorus and total Kjeldahl nitrogen in the upper level of the Nitrate Cell. Continued operation of the pilot demonstration project resulted in lower cell counts, as determined by phospholipid fatty acids (Table 16). However, this could also result from seasonal variations rather than the pilot demonstration itself.

b. Contaminant Distribution

Locations of the post-test core samples have been presented in Figure 35, with the pre-test and mid-test core sample locations also included for reference. Individual core data have been archived in Appendix A, and the summed data for each core location (cumulative mass) have been presented in Table 5. Cumulative mass contours were generated from each dataset to facilitate interpretation of the extent of removal. Contours were generated using Surfer software for Windows, and then AutoCAD was used to establish cell boundaries and provide mass estimates at various times within each treatment cell (Dan West, Computer Data Services Inc, personal communication). This method was also used to re-evaluate the pre-test conditions for the initial site characterization to provide better mass estimates for comparison. The contour plots for BTEX, BTEXTMB, and JP-4 are shown in Figures 37-39. As has been discussed previously, some of the core locations in the Interim Performance Evaluation were in areas not adjacent to those sampled for the initial site characterization, and consequently produced samples that were more contaminated than those previously. This had the net effect of showing no significant removal in the more contaminated region of the Nitrate Cell (Figure 37a, b). However, in most cases, the lower mass contour levels were shifted towards the contaminant source zone during this time, indicating remediation on the eastern part of the treatment cells.

Substantial remediation was more evident between the Interim and the Final Performance Evaluations (Figure 37b, c). The curvature of the zero-level contour within the stripped plot of the Nitrate Cell suggests more remediation within the stripped plot than outside (Figure 37c). Similar changes in contour profiles were observed for BTEXTMB, although no effect of the stripped plots could be observed (Figure 38). In contrast, the JP-4 profiles were quite different (Figure 39). Operation for the first three months appeared to have "smoothed out" the hot spots, although again this could be an artifact caused by the dissimilarity between the relative core locations for the two sampling events (Figure 39a, b). Unlike the case with BTEX and BTEXTMB, continued operation did not simply "push" the profiles toward the original source area, but appeared to have redistributed the JP-4 to a much greater extent (Figures 37c,

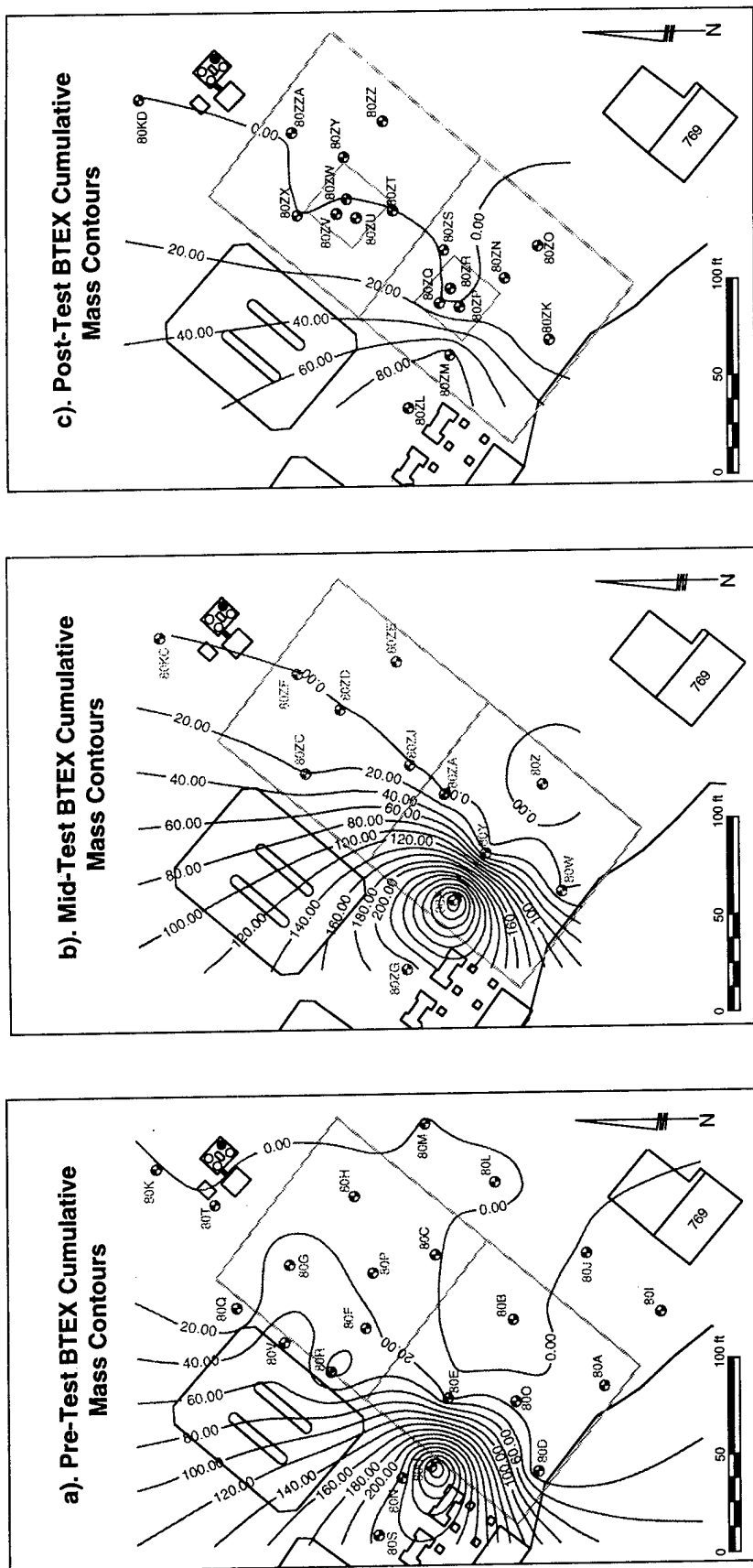
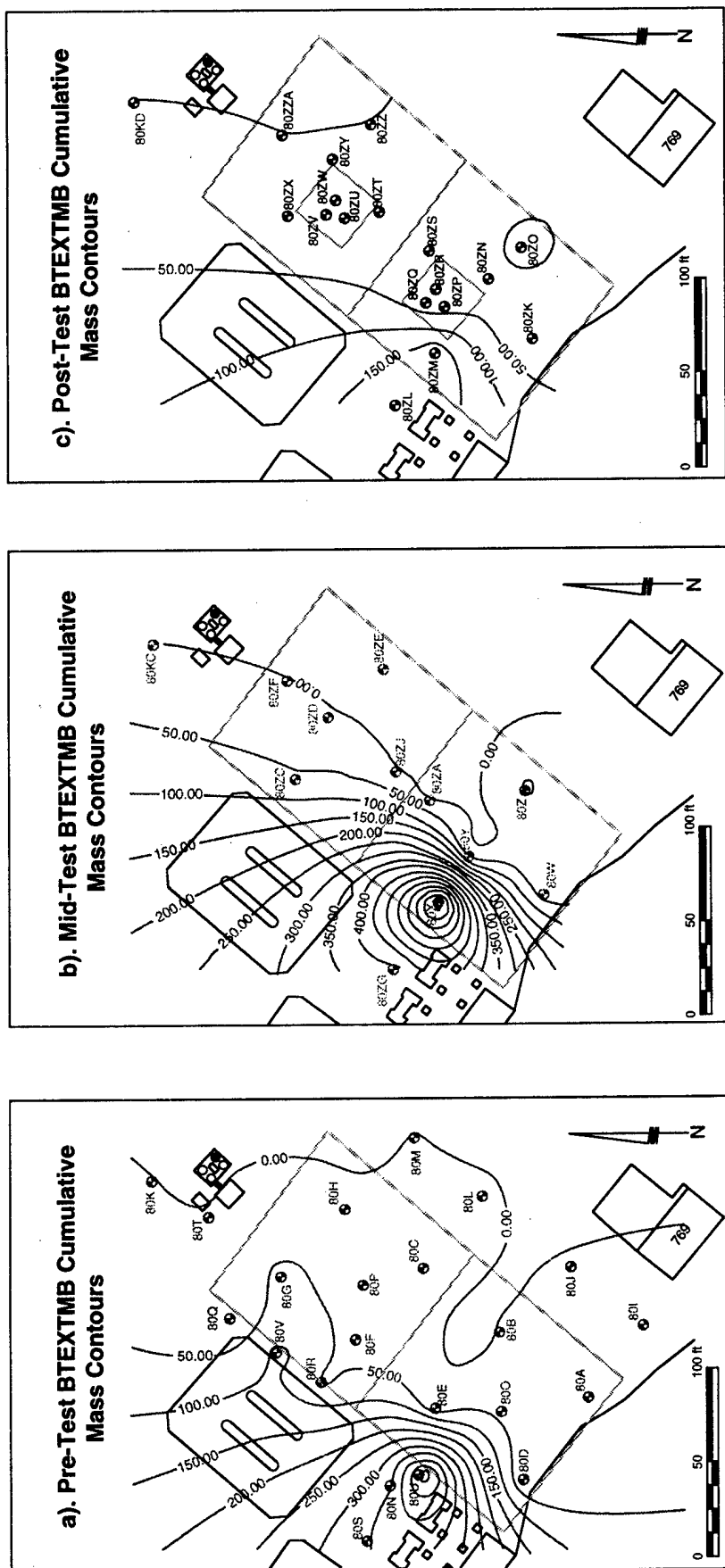


Figure 37. Mass Removal of BTEX Based on Core Analyses. Shown are Cumulative Mass Contours (g/m^2) of BTEX Based on Cores Taken a) Prior to Remediation, b) During Interim Performance Evaluation, and c) During Final Performance Evaluation.



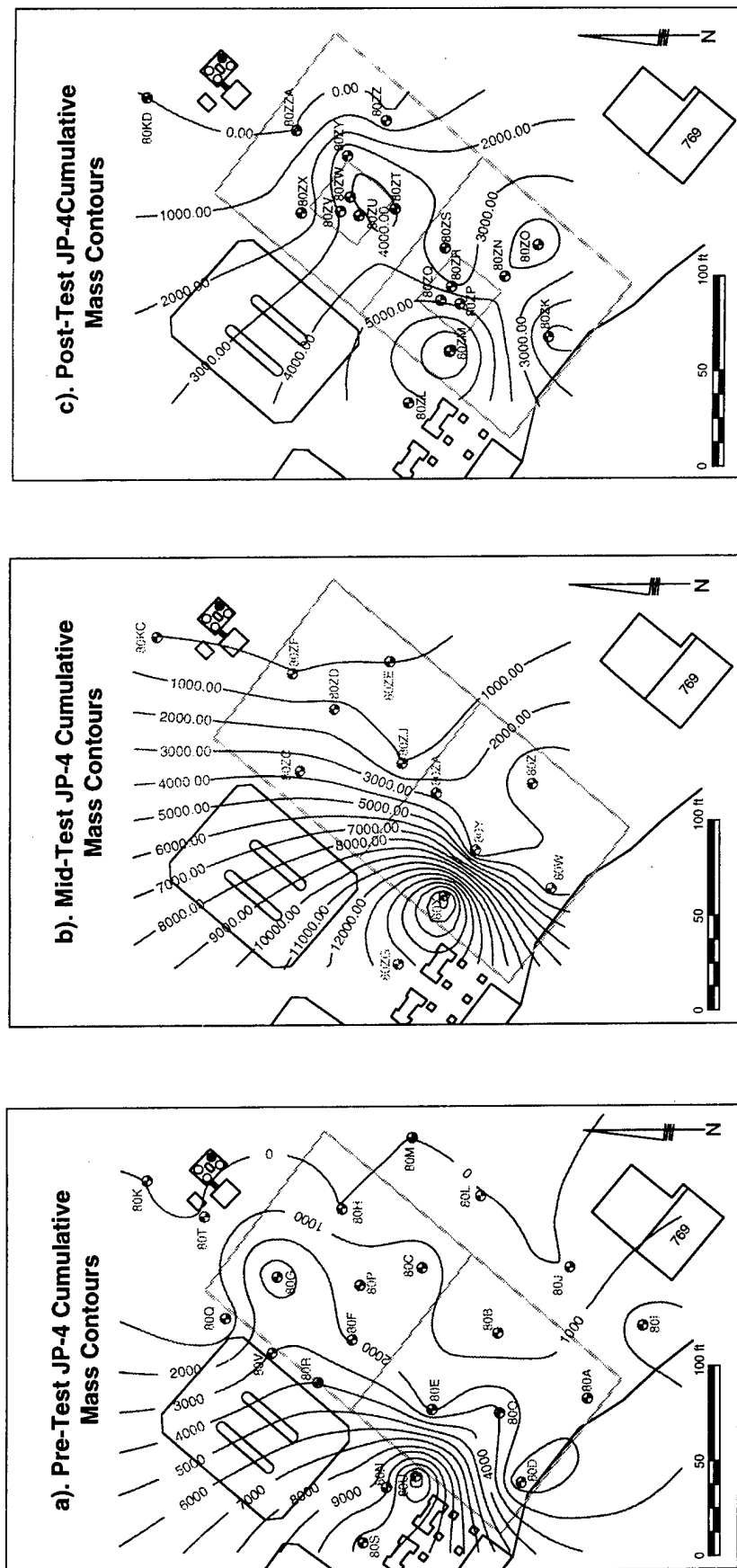


TABLE 19. MASS ESTIMATES OF CONTAMINANT GROUPS WITHIN TREATMENT CELL BOUNDARIES, BASED UPON CORE ANALYSES

Treatment Cell	Performance Evaluation	BTEX (kg)	BTEXTMB (kg)	JP-4 (kg)
Nitrate Cell	Initial	34.3	57.8	2380
	Interim	70.8	160.0	5870
	Final	20.4	53.7	3700
% Mass reduction	Interim vs Final	71.2	66.4	37.0
Control Cell	Initial	13.3	25.5	1510
	Interim	13.4	32.9	1750
	Final	3.1	11.5	1940
% Mass reduction	Interim vs Final	76.6	65.0	-10.9

38c, 39c). This is actually preferable, because the weathered hydrocarbons can then provide further sorptive capacity for BTEXTMB that continues to leach from the source area. In addition, this redistribution can help natural attenuation processes to become more effective, since toxicity effects associated with high fuel concentrations may be reduced. Mass estimates for these parameters are shown in Table 19. Mass reductions were calculated for the Interim versus the Final Performance Evaluation, since core locations corresponded more closely between these two events. Even though the Nitrate Cell contained 2-4 times more contaminants on a weight basis, the percent reduction was equivalent to that of the Control Cell. Based on core data from the Interim and Final Performance Evaluations, BTEXTMB was reduced by $66 \pm 1\%$ in both treatment cells, equivalent to a mass loss of 106 kg and 21 kg in the Nitrate Cell and Control Cell, respectively. This mass reduction led to a corresponding reduction in aqueous BTEXTMB concentrations (Appendix C). In fact, one year after the study was completed, the cluster wells in the centers of both treatment plots still showed the effects of the pilot study, with an average reduction in aqueous BTEXTMB concentrations of $80 \pm 21\%$ and $87 \pm 12\%$ in the Nitrate and Control Cells, respectively, compared to cluster well concentrations at the beginning of the study. In contrast, JP-4 decreased by 37% (2170 kg) in the Nitrate Cell and increased by 11% (210 kg) in the Control Cell (Table 19). Based on this information, both treatment cells

were remediated to the same extent, at least as regards the monoaromatic hydrocarbons. However, it is not possible to differentiate between remediation by biological activity versus soil washing based on these data alone.

Evidence of biological activity is provided by evaluating the changes in mass reduction of specific contaminants within and outside of the stripped plot for each treatment cell. In this analysis, estimates of mass reduction outside of the stripped plots were made by comparing cumulative masses for specific contaminants in adjacent core locations taken during the Interim and the Final Performance Evaluations. For the Nitrate Cell, Locations 80X and 80ZA were compared to 80ZM and 80ZS, respectively (Figure 35). For the Control Cell, Locations 80ZB and 80ZC were compared to 80ZT and 80ZX, respectively. Estimates of mass reduction within the stripped plots were made by comparing the average cumulative masses for specific contaminants in the same outside core locations taken during the Interim Performance Evaluations with those for the three separate locations within the stripped plots. Thus, for the Nitrate Cell, Locations 80X/80ZA were compared to 80ZP, 80ZQ, and 80ZR (Figure 35). For the Control Cell, Locations 80ZB/80ZC were compared to 80ZU, 80ZV, and 80ZW. This method of comparison provided fairly good reproducibility of results, considering that these measurements represent field data from a very heterogeneous environment. The data are tabulated in Tables 20 and 21.

In the Nitrate Cell, there was a significant increase in the mass reduction of the monoaromatic hydrocarbons within the stripped plot area compared to immediately outside of it, and this was observed to a lesser extent with JP-4 as well (Table 20). Mass reduction of BTEX increased from $60 \pm 22\%$ outside of the stripped plot to $100 \pm 4\%$ within the stripped plot area, and the corresponding mass reduction for BTEXTMB increased from $53 \pm 17\%$ to $96 \pm 4\%$. The stripped plot also enhanced removal in the Control Cell, although the extent was less (Table 21). Mass reduction of BTEX in the Control Cell increased from $89 \pm 16\%$ outside of the stripped plot to $96 \pm 7\%$ within the stripped plot area, and the corresponding mass reduction for BTEXTMB increased from $41 \pm 42\%$ to $68 \pm 28\%$. In contrast, there was no net mass reduction of JP-4 at most of the locations in the Control Cell (Table 21). Considering that there was generally less contamination initially within the Control Cell than the Nitrate Cell, the greater extents of removal in the Nitrate Cell argue against simple flushing as being the only removal mechanism. The discrepancy between these results and the net mass removals shown in Table 19 is probably due to the fact that the stripped plot within the Nitrate Cell provided greater transport of nitrate to the subsurface in this region than in the rest of the Nitrate Cell (see Figure 34), and mass removals were therefore correspondingly greater. This would lead to better performance in the Nitrate Cell than in the Control Cell, based on this comparison. Further evidence of biological activity is provided by evaluating mass removals of the different isomers, which are arranged in the order of increasing hydrophobicity in Figure 40. In the Nitrate Cell, removals of the xylene isomers and the trimethylbenzene isomers varied extensively outside of the stripped plot, but not according to the degree of hydrophobicity (Figure

TABLE 20. MASS REDUCTION ESTIMATES FOR SPECIFIC CONTAMINANTS
WITHIN AND OUTSIDE OF STRIPPED PLOT IN NITRATE TREATMENT CELL

Treatment Cell	Area	Core	Date	Parameter	BZ	TOL	ETBZ	PXYL	MXYL	OXYL	MESIT	PSCU	TMB	BTEX	BTEXTMB	JP-4
Nitrate Cell	Outside of Stripped Plot	80X 80ZM	Aug-94	Cum Mass (g/m ²)	0.194	0.224	73.841	83.158	207.992	0.402	232.549	139.437	52.604	365.81	790.40	17967
			May-95	Cum Mass (g/m ²)	0.064	0.043	18.374	23.009	48.966	0.161	20.478	52.810	15.437	90.62	179.34	7576
		80ZA 80ZS	Aug-94	Fraction Removed	0.673	0.809	0.751	0.723	0.765	0.600	0.912	0.621	0.707	0.752	0.773	0.578
			May-95	Cum Mass (g/m ²)	<0.001	0.011	0.002	0.005	0.018	0.027	1.484	0.679	0.626	0.06	2.83	2703
	Outside of Stripped Plot	80X/80ZA 80ZM/80ZS	Aug-94	Cum Mass (g/m ²)	<0.001	0.003	<0.001	0.014	0.011	0.005	0.037	0.855	0.405	0.03	1.33	2069
			May-95	Fraction Removed	N/A	0.692	1.000	-2.036	0.358	0.795	0.975	-0.260	0.353	0.448	0.530	0.235
		80X/80ZA 80ZP	Aug-94	Average Fraction Removed	0.673	0.751	0.876	-0.656	0.561	0.698	0.944	0.181	0.530	0.600	0.652	0.407
			May-95	Standard Deviation	N/A	0.083	0.176	1.951	0.288	0.138	0.045	0.623	0.250	0.215	0.172	0.243
	Within Stripped Plot	80X/80ZA 80ZQ	Aug-94	Cum Mass (g/m ²)	0.097	0.117	36.922	41.581	104.005	0.215	117.016	70.058	26.615	182.94	396.62	10335
			May-95	Cum Mass (g/m ²)	<0.001	0.005	0.018	0.312	0.143	0.084	10.155	16.290	5.894	0.56	32.90	4598
		80X/80ZA 80ZR	Aug-94	Fraction Removed	1.000	0.960	1.000	0.993	0.999	0.609	0.913	0.767	0.779	0.997	0.917	0.555
			May-95	Cum Mass (g/m ²)	0.097	0.117	36.922	41.581	104.005	0.215	117.016	70.058	26.615	182.94	396.62	10335
Nitrate Cell	Within Stripped Plot	80X/80ZA 80ZP	Aug-94	Cum Mass (g/m ²)	<0.001	<0.001	0.001	0.012	<0.001	0.001	0.105	8.940	1.946	0.02	11.01	4631
			May-95	Fraction Removed	1.000	1.000	1.000	1.000	1.000	0.994	0.999	0.872	0.927	1.000	0.972	0.552
		80X/80ZA 80ZR	Aug-94	Cum Mass (g/m ²)	0.097	0.117	36.922	41.581	104.005	0.215	117.016	70.058	26.615	182.94	396.62	10335
			May-95	Cum Mass (g/m ²)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.356	0.129	<0.01	0.49	2590
Nitrate Cell	Within Stripped Plot	80X/80ZA 80ZP	Aug-94	Fraction Removed	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.995	0.995	1.000	0.999	0.749
			May-95	Cum Mass (g/m ²)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.995	0.995	1.000	0.999	0.749
		80X/80ZA 80ZQ	Aug-94	Average Fraction Removed	1.000	0.987	1.000	0.997	1.000	0.868	0.971	0.878	0.900	0.999	0.963	0.619
			May-95	Standard Deviation	0.000	0.023	0.000	0.004	0.001	0.224	0.050	0.114	0.111	0.002	0.042	0.113

TABLE 21. MASS REDUCTION ESTIMATES FOR SPECIFIC CONTAMINANTS
WITHIN AND OUTSIDE OF STRIPPED PLOT IN CONTROL TREATMENT CELL

Treatment Cell	Area	Core	Date	Parameter	BZ	TOL	ETBZ	PXYL	MXYL	OXYL	MESIT	PSCU	TMB	BTEX	BTEXTMB	JP-4
Control Cell	Outside of Stripped Plot	80ZB 80ZT	Aug-94	Cum Mass (g/m ²)	0.002	0.010	0.025	0.121	0.161	0.023	1.060	1.287	1.441	0.34	4.13	1030
			May-95	Cum Mass (g/m ²)	<0.001	<0.001	0.003	0.025	0.031	0.016	1.892	0.676	1.051	0.07	3.69	4224
				Fraction Removed	1.000	1.000	0.878	0.793	0.808	0.311	-0.785	0.475	0.271	0.781	0.105	-3.101
		80ZC 80ZX	Aug-94	Cum Mass (g/m ²)	0.002	0.022	0.650	4.769	7.720	4.315	12.371	18.596	9.098	17.48	57.54	3717
			May-95	Cum Mass (g/m ²)	<0.001	0.009	<0.001	<0.001	<0.001	<0.001	7.250	5.140	4.632	0.01	17.03	1501
				Fraction Removed	1.000	0.611	1.000	1.000	1.000	1.000	0.414	0.724	0.491	1.000	0.704	0.596
	Within Stripped Plot	80ZB/80ZC 80ZT/80ZX	Average Fraction Removed Standard Deviation		1.000	0.806	0.939	0.896	0.904	0.656	-0.186	0.599	0.381	0.890	0.405	-1.252
					0.000	0.275	0.086	0.147	0.136	0.487	0.848	0.176	0.156	0.155	0.423	2.615
			Aug-95 May-95	Cum Mass (g/m ²) Cum Mass (g/m ²) Fraction Removed	0.002 <0.001 1.000	0.016 <0.001 1.000	0.338 0.065 0.807	2.445 0.213 0.913	3.940 0.388 0.902	2.169 0.422 0.806	6.715 11.904 -0.773	9.942 3.811 0.617	5.270 3.026 0.426	8.91 1.09 0.878	30.84 19.83 0.357	2374 4025 -0.696
		80ZB/80ZC 80ZV	Aug-95 May-95	Cum Mass (g/m ²) Cum Mass (g/m ²) Fraction Removed	0.002 <0.001 1.000	0.016 0.002 0.890	0.338 <0.001 1.000	2.445 0.003 0.999	3.940 0.004 0.999	2.169 <0.001 1.000	6.715 4.584 0.317	9.942 0.626 0.937	5.270 0.612 0.884	8.91 0.01 0.999	30.84 5.83 0.811	2374 3085 -0.300
			Aug-95 May-95	Cum Mass (g/m ²) Cum Mass (g/m ²) Fraction Removed	0.002 <0.001 1.000	0.016 0.002 0.859	0.338 0.009 0.972	2.445 0.033 0.986	3.940 0.023 0.994	2.169 0.015 0.993	6.715 3.526 0.475	9.942 0.337 0.966	5.270 0.498 0.906	8.91 0.08 0.991	30.84 4.44 0.856	2374 4207 -0.772
	Within Stripped Plot	80ZB/80ZC 80ZV/80ZW	Average Fraction Removed Standard Deviation		1.000	0.916	0.927	0.966	0.965	0.933	0.007	0.840	0.738	0.956	0.675	-0.589
					0.000	0.074	0.104	0.046	0.055	0.110	0.679	0.194	0.271	0.068	0.276	0.254

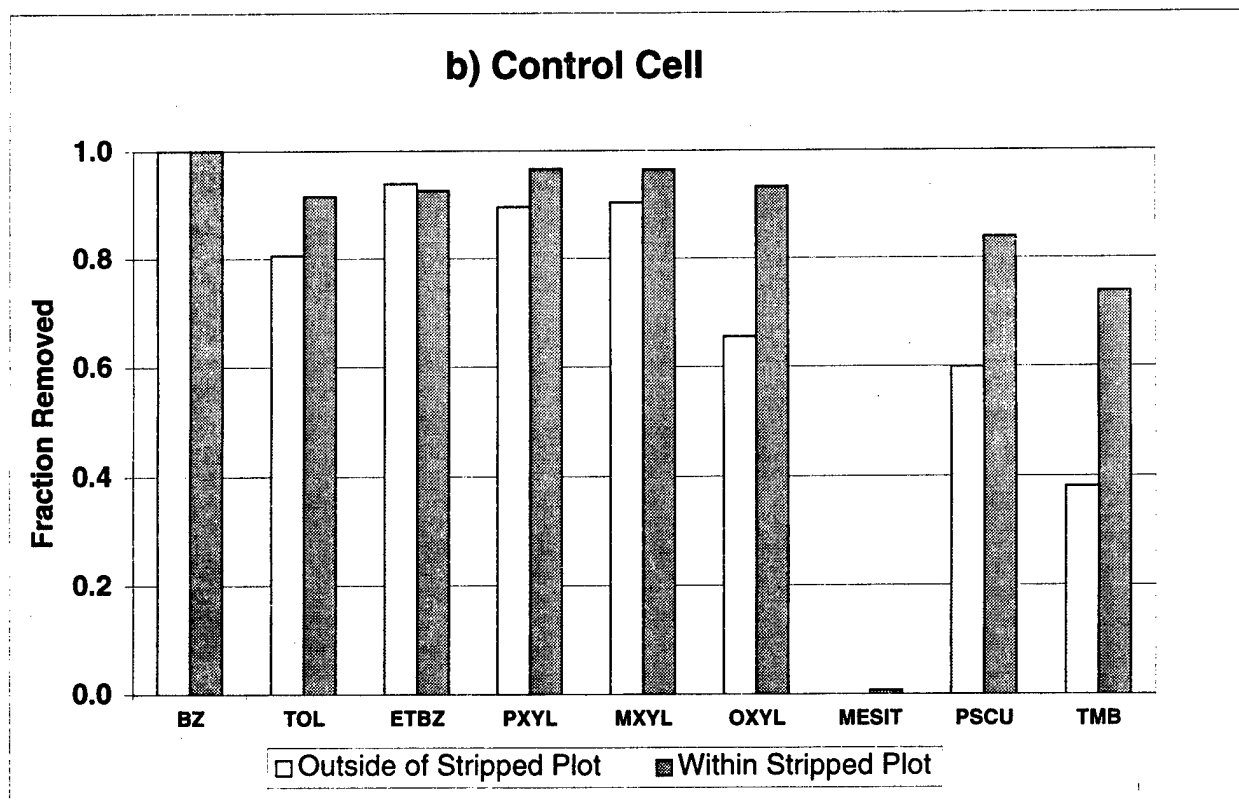
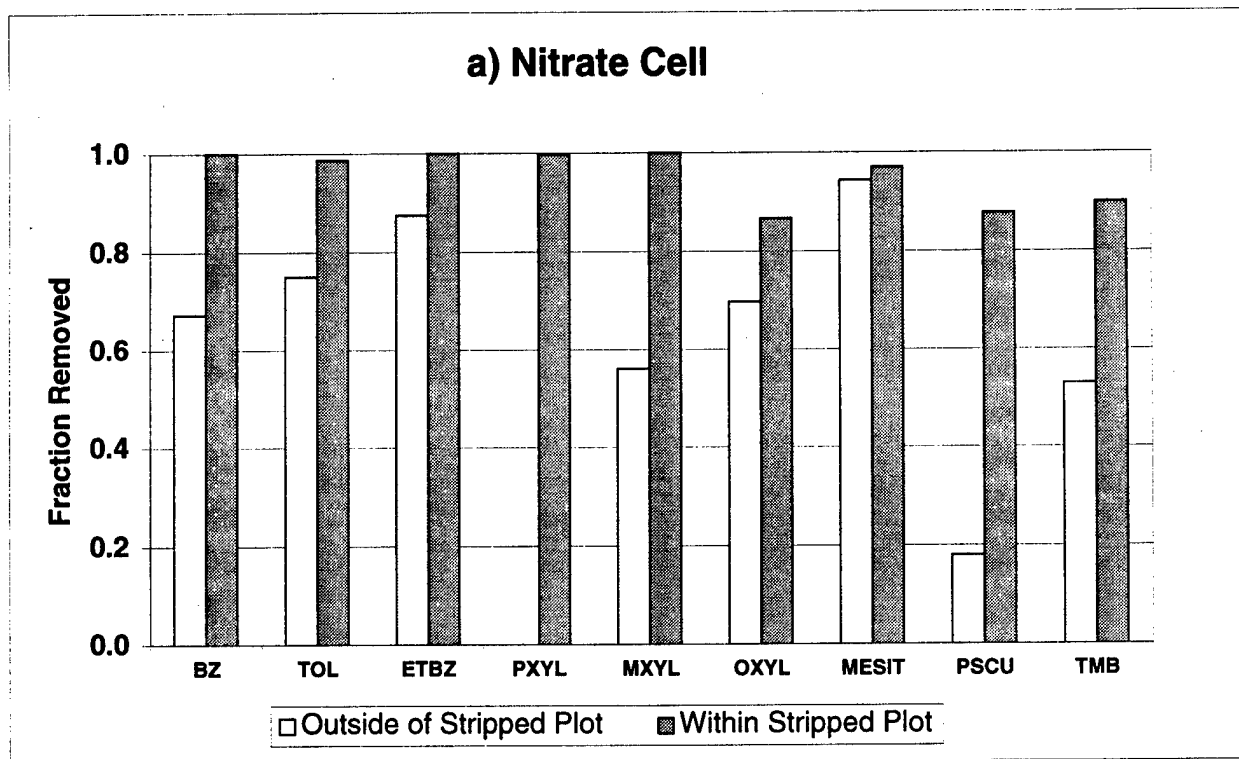


Figure 40. Effect of Stripped Plots on Mass Removal of Selected Contaminants in a) Nitrate Cell and b) Control Cell. Negative Fractions are Shown as No Removal.

40a). For example, if the mass removals were due solely to soil washing, then OXYL should exhibit less removal than PXYL and MXYL. Similarly, TMB should exhibit less removal than MESIT and PSCU. This was obviously not the case in the Nitrate Cell, which implies that other removal processes were operative. Mass removals of all isomers generally increased within the stripped plot area, which again could indicate enhanced soil washing and/or bioremediation. However, if enhanced soil washing were the only removal process, then the same result would be expected in the stripped plot of the Control Cell, and it was not (Figure 40b). Mesitylene was recalcitrant both within and outside of the stripped plot in the Control Cell, although there was quite a bit of variability and removals ranged from -79% to 48% (Table 21). In contrast, as has been observed previously with water and core data, mesitylene was quite labile under denitrifying conditions, both within and outside of the stripped plot in the Nitrate Cell (Figure 40). In summary, although it is not possible to separate out the effects of soil washing from bioremediation with these data, there was active bioremediation which was indeed responsible for part of the contaminant reduction.

c. Changes in Microbial Populations

As with the two previous performance evaluations, core samples were obtained for analysis of microbial populations and sediment toxicity by personnel from Rice University. These studies will be published in detail elsewhere (M. Thomas, personal communication), and are briefly described here. Preliminary analysis of the results from the microbial population counts indicates that the number of total denitrifiers in the Nitrate Cell increased during the Interim Performance Evaluation, but then declined to initial levels by the time of the Final Performance Evaluation. However, the number of JP-4-utilizing denitrifiers, heterotrophs, and JP-4 degraders declined and then increased during the corresponding period, even in the uncontaminated control samples (Thomas et al, unpublished data). These data suggest that seasonal factors unrelated to bioremediation may have affected the microbial ecology at the site. However, it is also possible that biological activity was enhanced in both treatment cells as a result of recharge application, and downgradient sample sites were positively affected as well. Some evidence for this is shown in the stimulation of protozoan activity, shown by increased numbers in the deeper subsurface as bioremediation proceeded (Table 22). The data in Table 22 are based on aerobic protozoa counts conducted in-house (Jim Sinclair, ManTech Environmental Services Inc) and are from the 1-foot intervals sampled for microbial characterization in the initial site characterization and subsequent performance evaluations. The data were obtained from several different core locations and are roughly arranged according to depth. In the Nitrate Cell, protozoan numbers increased substantially during the first four months and were still high, but sporadic, in the deeper regions during the Final Performance Evaluation. Numbers downgradient of the Nitrate Cell did not change much (Location 80JB-80JC), whereas numbers in the previously uncontaminated control site, which became downgradient of the Control Cell during pilot operation, showed a similar trend to that of the Nitrate Cell (80KB-

TABLE 22. CHANGES IN AEROBIC PROTOZOAN NUMBERS DURING PILOT DEMONSTRATION PROJECT

Pilot Demonstration Area	Initial Site Characterization				Interim Performance Evaluation				Final Performance Evaluation			
	Core Sample	Lo (ft)	Hi (ft)	Protozoa (per g)	Core Sample	Lo (ft)	Hi (ft)	Protozoa (per g)	Core Sample	Lo (ft)	Hi (ft)	Protozoa (per g)
Nitrate Cell	80BA3	1.0	2.2	350,000	80Z2	1.3	2.4	7,900	80ZO2	1.1	2.2	24,000
	80BA2	2.2	3.4	92,000	80W2	2.3	3.4	24,000	80ZK2	2.1	3.2	5
	80AA2	2.3	3.4	45,000	80ZA2	2.3	3.4	240,000	80ZO1	2.2	3.3	240,000
	-	-	-	-	80Z1	2.4	3.5	4,100	80ZS2	2.3	3.3	35,000
	-	-	-	-	80X2	2.5	3.8	49,000	80ZM2	2.6	3.4	8
	80EB2	3.2	4.2	240	80W1	3.4	4.5	13,000	80ZK1	3.2	4.3	240
	80AA1	3.4	4.5	<2	80ZA1	3.4	4.5	41	80ZS1	3.3	4.3	>1,600,000
	80EB1	4.2	5.2	2	80X1	3.8	5.0	<2	80ZM1	3.4	4.5	<2
	80AA7	4.5	5.6	<2	80W4	4.8	5.9	49,000	80ZS4	4.6	5.7	5,400
	80BA5	4.5	5.6	5	80ZA4	4.8	5.9	79,000	80ZO3	4.7	5.8	<2
	-	-	-	-	80Z4	4.9	6.0	240	80ZM4	5.1	5.9	33
	-	-	-	-	80X4	5.3	6.4	2	80ZK3	5.7	6.8	7
	80EB5	6.5	7.5	<2	-	-	-	-	-	-	-	-
Downgradient of Nitrate Cell	80JB2	2.5	3.5	8	80JC2	2.3	3.4	<2	80JD1	2.5	3.6	24,000
	80JB1	3.5	4.5	19	80JC1	3.4	4.5	2	80JD4	4.8	5.9	33
	80JB5	6.0	7.0	5	80JC3	5.9	7.0	<2	80JD3	5.9	6.9	23
Downgradient of Control Cell (Previously Used as Control Site)	80KB2	3.2	4.4	240	-	-	-	-	80KD1	3.7	4.8	13
	80KB1	4.4	5.5	2	80KC2	5.0	6.0	13,000	80KD4	5.1	6.2	2,400
	80KB6	5.5	6.7	<2	80KC1	6.0	7.5	540	80KD3	6.2	7.3	79
	-	-	-	-	80KC4	7.8	8.9	24,000	80KD6	7.6	8.7	1,700

80KD). For reference, the Nitrate Cell is about 1-2 feet lower and 1-2 feet higher than Locations 80K and 80J, respectively. This information, in addition to the core and ground water analyses, further indicates that bioremediation may be occurring in the Control Cell as well as the Nitrate Cell, since an increased microbial population is required to sustain the higher numbers of protozoans downgradient.

c. Changes in Sediment Toxicity

Core samples were also obtained for analysis of sediment toxicity by personnel from Oklahoma State University. These studies are being published in detail elsewhere (Bantle, 1996). In brief, the general pattern of decreasing toxicity with further distance from the source area did not change, and there was evidence of reduced toxicity in both treatment cells based on cores taken during the initial site characterization and the Final Performance Evaluation. However, toxicity varied both longitudinally and with depth, and there was often no consistent pattern which could be attributed to operation of either treatment cell. In addition, there was no clear reduction in toxicity in either of the stripped plots compared to their respective treatment cells, and in some instances core samples beneath the stripped plots were more toxic than those outside of the stripped plots. When different soil layers were taken into account, the following order of toxicity was derived:

Mortality:	SS > NC > CC/SP > NC/SP > CC > UCS
Malformation:	SS > CC/SP > NC > NC/SP > CC > UCS
Stunted Growth:	SS > NC/SP > NC > CC/SP > CC > UCS

where SS = Spill Source, NC = Nitrate Cell, NC/SP = Nitrate Cell Stripped Plot, CC = Control Cell, CC/SP = Control Cell Stripped Plot, and UCS = Uncontaminated Control Site. In all cases, the only differences emerge between the respective toxicities of the Nitrate Cell, the Nitrate Cell Stripped Plot, and the Control Cell Stripped Plot, where contaminant levels are intermediate. For mortality and malformation, the Nitrate Cell Stripped Plot was less toxic than the Nitrate Cell, and the Control Cell Stripped Plot was more toxic than the Control Cell. Consideration of the cumulative mass contours of BTEXTMB (Figure 38c) and JP-4 (Figure 39c) show very different ranges of these contaminant groups within these areas, which may help to explain some of the variability. Although the causative agents for these toxicity indices are unknown, they do not appear to be directly related to the by-products or intermediates of nitrate-based bioremediation, since nitrate levels were highest beneath the Nitrate Cell Stripped Plot, and it represents the lower of the intermediate toxicity group in most of the cases above.

FETAX data were further evaluated to assess the overall effects of remediation on sediment toxicity (Figure 41). FETAX analyses from the different depths sampled at any given location during the Final Performance Evaluation were pooled and weighted to provide a direct comparison with the identical interval sampled during

the Interim Performance Evaluation. Similar comparisons could not be made with the samples taken prior to remediation, since different depth intervals were used for the initial FETAX assay. Based on the contaminant data obtained prior to remediation, we were able to delineate the sample depths suspected of having the greatest toxicity at each location, and hence this analysis targeted the most contaminated intervals. Data for mortality indicate that the sediment toxicity for the Interim Performance Evaluation generally correlated with JP-4 concentrations (Figure 41a). Following remediation, areas of high toxicity still exist, but in general there has been substantial toxicity reduction beneath both treatment cells, particularly in the areas beneath and adjacent to the stripped plots (Figure 41b). For some locations (eg, 80Z, 80ZO), sediments still cause 100% mortality to the embryos, and it is unclear why these are still quite toxic while other adjacent cores (eg, 80ZK) have been substantially detoxified. Although site heterogeneity can indeed be a problem in some of these locations, additional work is clearly needed to better define the effects of nitrate-based bioremediation on toxicity reduction.

E. TREATABILITY STUDIES

Post-test treatability studies were conducted with aquifer material obtained using the anaerobic glovebox during the Final Performance Evaluation. These tests were conducted to better define microbial activity and function, and to help assess the role of the various microbial populations in contaminant reduction. The general procedures and methods of microcosm preparation were the same as those used in the initial site characterization, and have already been discussed (Section IIC). However, some of the tests were modified to address additional objectives, and are discussed in greater detail.

1. Distribution of Microbial Activity

As with the initial site characterization, core samples were obtained from three depths each at four locations within the Nitrate Cell, as well as at one location downgradient of the Nitrate Cell and one location downgradient of the Control Cell. Microcosms were prepared similar to those done for the previous survey, and spiked with nutrients, nitrate, and mixed BTEXTMB. In addition, live controls (not receiving nitrate) were prepared for each of the core samples to evaluate the contribution of microbial processes other than nitrate reduction for BTEXTMB removal. At selected time intervals, three replicate viable microcosms, plus one live control and one poisoned control, were sacrificed and analyzed for BTEXTMB, nitrate, nutrients, and pH to evaluate BTEXTMB biodegradation under denitrifying conditions.

There was variable activity in the selected core samples, although in general most of the alkylbenzenes were degraded, except for benzene and 1,2,3-trimethylbenzene (Figure 42). The combined results (as BTEXTMB) are shown in

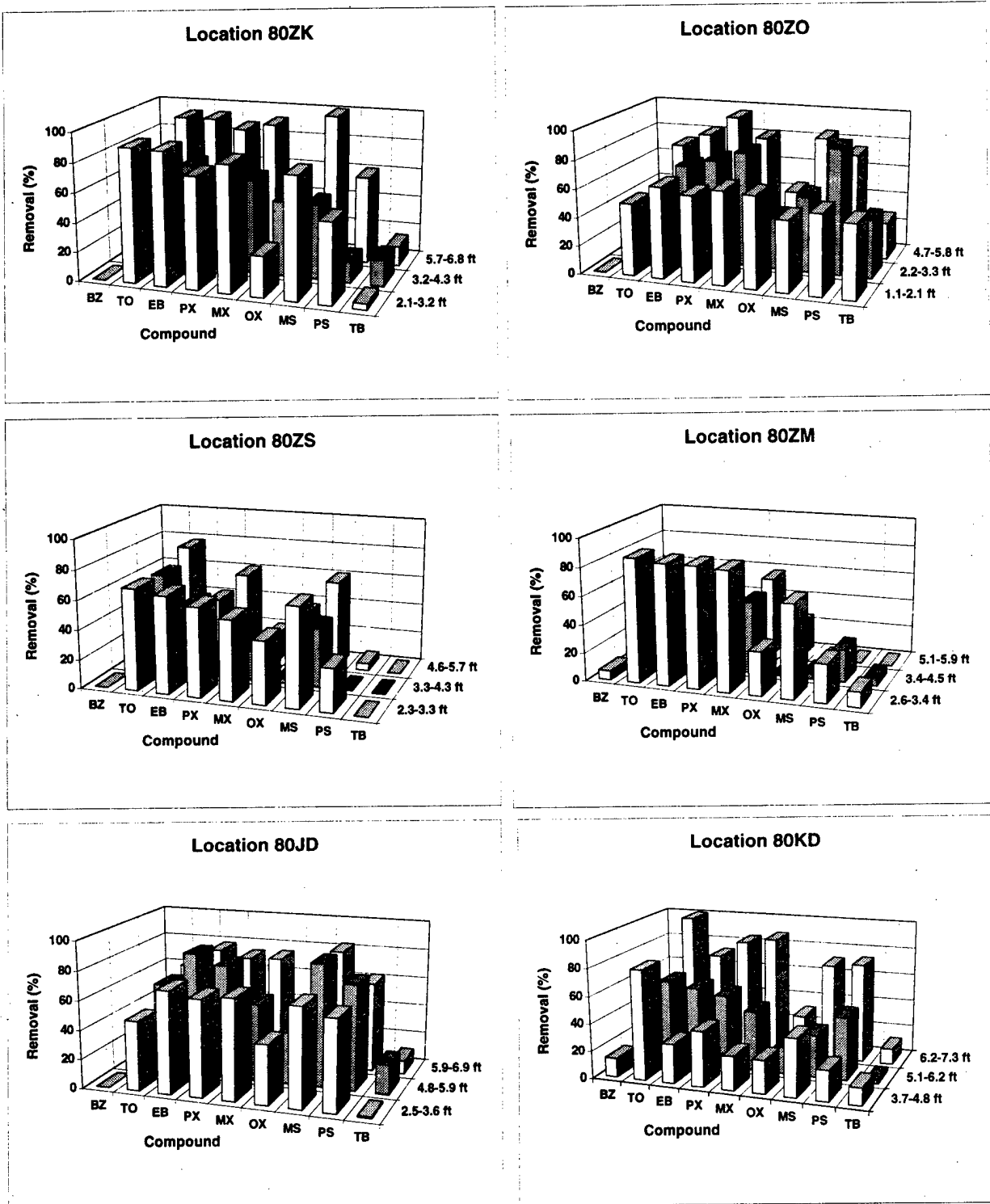


Figure 42. Percent Removal of Individual BTEXTMB Compounds in Post-Test Cores Under Denitrifying Conditions. Removals are Corrected for Loss in Controls, and Negative Removals are Shown as Zero. Mean of Three Replicates per Set.

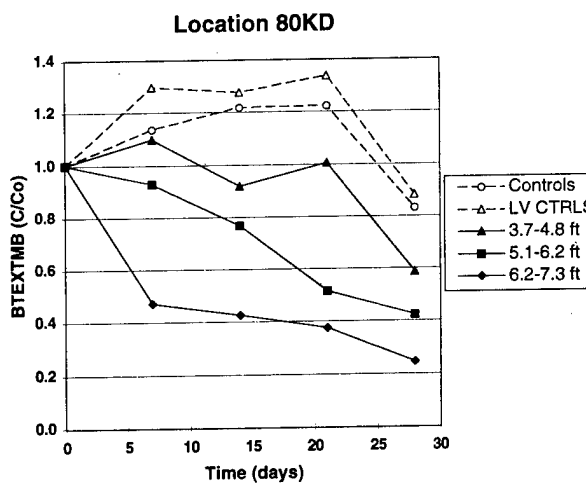
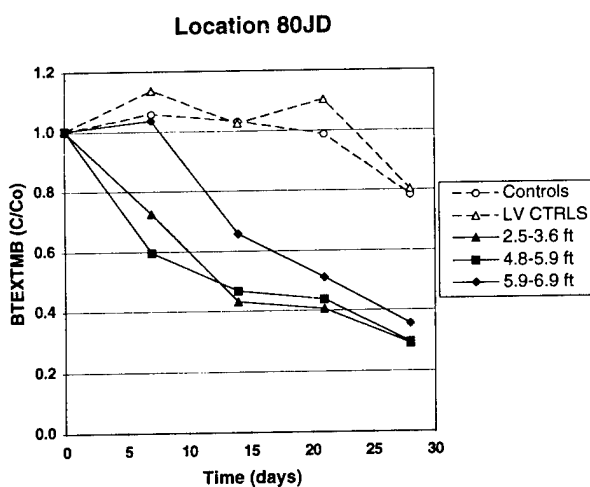
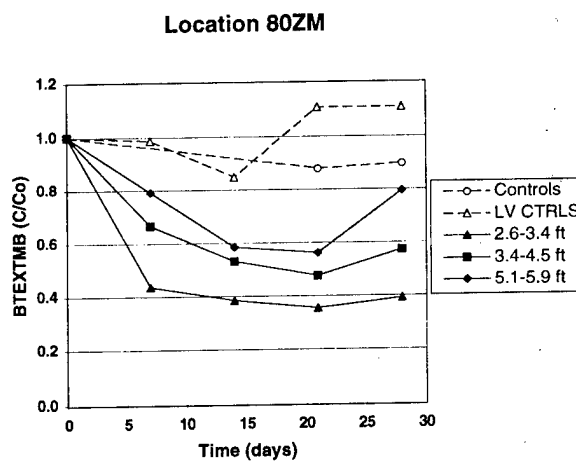
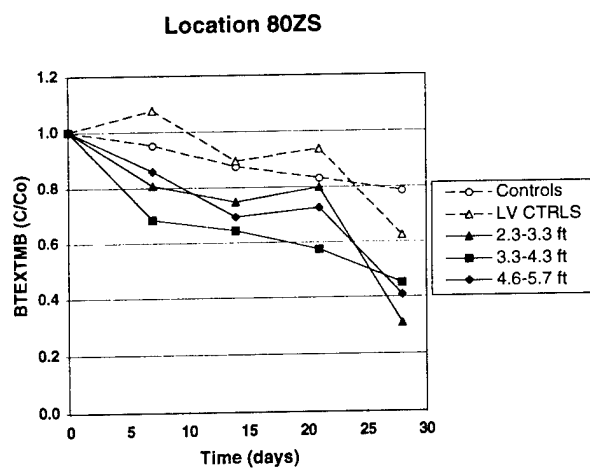
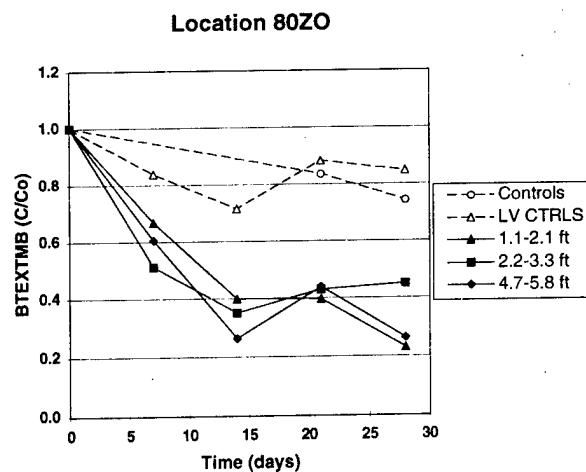
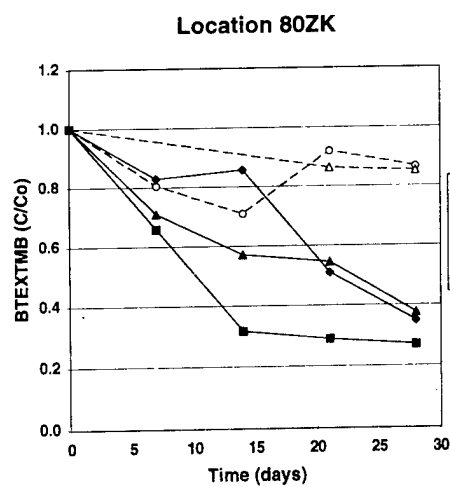


Figure 43. Combined BTEXTMB Removal in Cores Taken from Pilot Demonstration Area During Final Performance Evaluation. Mean of Three Replicates Per Set.

Figure 43. There was little consistent improvement in the degradation rate or extent in the Nitrate Cell cores compared to the activity observed during the initial site characterization (cf Figures 11 and 42, Figures 12 and 43). Similarly, there was no clear enhancement in the biodegradation of one compound versus another. Because the post-test cores were obtained from different locations than the pre-test cores, a direct comparison cannot be made. However, in certain cases the core locations were similar enough to allow a rough comparison. For example, Cores 80E (pre-test) and 80ZM (post-test) were obtained from approximately the same location. In this case, operation of the pilot demonstration project caused the microbial activity to decline at the lowest depth but increase in the upper depths (cf Figures 12 and 43). For some reason the microcosms for the mid-depth core of the 80ZM series showed little BTEXTMB removal activity in the last sample set (Figure 43); the cause of this is unknown. Cores 80BA (pre-test) and 80ZO (post-test) can similarly be compared, and the only difference was a slight increase in the rate of nitrate-based BTEXTMB removal at the lower depth (cf Figures 12 and 43). In most cases, there was little removal of BTEXTMB in the live controls relative to the poisoned controls, indicating that nitrate was required for anaerobic biodegradation of BTEXTMB in these microcosms, at least within this time period (Figure 43).

In contrast to these results, there was a definite enhancement in microbial activity downgradient of the Nitrate Cell (cf Figures 11 and 42, Figures 12 and 43). Although elevated nitrate concentrations were not detected in downgradient wells, transport of denitrifying microorganisms from the Nitrate Cell may indeed have occurred. However, another explanation is that operation of the pilot demonstration project could have resulted in transport of organic carbon or other nutrients which promoted changes in the microbial populations. This may be part of the reason that enhanced activity was also observed in the middle depth interval of Location 80K, which should have been hydrologically isolated from the Nitrate Cell but not from the Control Cell (cf Figures 11 and 42, Figures 12 and 43). However, the extent of this enhancement was not as great, and could have been due to other factors, including increased moisture content from the elevated water table.

2. Dissimilatory Nitrate Reduction to Ammonia

In the aforementioned microcosm test, two of the core samples (80ZS1 and 80ZS4, Table 18) were spiked with ^{15}N -nitrate to evaluate whether nitrate-nitrogen was being reduced to ammonia-nitrogen through dissimilatory nitrate reduction to ammonia, rather than to nitrous oxide and dinitrogen through denitrification. As discussed previously, dissimilatory nitrate reduction to ammonia would more likely be expected under electron acceptor-limited conditions, and demonstration of the process in the microcosm test would provide supporting evidence that nitrate was being used as an electron acceptor in the contaminated subsurface. These microcosms were prepared, incubated, sampled, and analyzed in an identical manner to the other sample sets, except that ^{15}N -sodium nitrate was used instead of ^{14}N -potassium nitrate.

After the routine sampling procedure was completed, the microcosm supernatants were analyzed for ^{14}N - and ^{15}N -ammonia by derivatization and GC/MS. In brief, the supernatant was made basic with NaOH and amended with pentafluorobenzoyl chloride to complex the ammonium ion, after which the complex was extracted with ethyl acetate and analyzed by GC/MS using a DB5-MS capillary column.

Results show that once nitrate and nitrite become limiting, production of ^{15}N -ammonia nitrogen begins to occur in the 80ZS1 microcosm supernatants after about Day 14 (Table 23). Production is not extensive (only approximately 4 mg/L $\text{NH}_4\text{-N}$), but is significant relative to controls. In contrast, little ^{15}N -ammonia nitrogen accumulates in the 80ZS4 microcosm supernatants, probably because the rate of nitrate reduction was much slower in this core sample and the microcosms had not yet become electron acceptor-limited (Table 23). These data demonstrate the potential for nitrate reduction to ammonia, which may help to explain the higher levels of ammonia-nitrogen found in water from the Nitrate Cell cluster wells. However, it is also possible that vegetative decay contributed to the increased ammonia-nitrogen levels. Regardless, these data indicate that dissimilatory nitrate reduction to ammonia can occur, although the extent of the contribution of this microbial process cannot be ascertained.

3. Alternate Electron Acceptors

To determine whether other anaerobic processes could have contributed to BTEXTMB removal in both the Nitrate and Control Cells, microcosms were prepared with core samples aseptically obtained from three depths at locations within the center of each cell. Replicate sets were spiked with nitrate and/or biocides to provide denitrifying and poisoned controls as described previously. In addition, one replicate set was spiked with ferric EDTA (approximately 5000 mg/L final concentration) to provide iron-reducing conditions. Two other replicate sets were reduced with sodium sulfide, and one of these reduced sets was spiked with sodium sulfate (approximately 150 mg/L SO_4^{2-} final concentration) to provide sulfate-reducing conditions whereas the other was unamended to provide methanogenic conditions. In addition to the standard analyses, microcosm supernatants were also analyzed for sulfate, thiosulfate, nitrous oxide, and methane. Microcosm supernatants were not analyzed for iron, because of anticipated problems with interpretations due to precipitation of iron species on the soil matrix. For the six time steps used in this study, this resulted in approximately 550 microcosms with over 5,000 individual analyses.

Because the size of this dataset makes it difficult to adequately address all of the results in this report, the following section provides a summary of the most relevant findings. In brief, in those cores which were metabolically active, biodegradation of BTEXTMB occurred predominantly under nitrate-and/or iron-reducing conditions (Figure 44). In the Nitrate Cell Cores, there was significant BTEXTMB removal at each depth under denitrifying conditions, although at two levels the extent of BTEXTMB

TABLE 23. PRODUCTION OF N-15 AMMONIA-NITROGEN FROM N-15 NITRATE REDUCTION IN SELECTED CORES COLLECTED FROM NITRATE CELL DURING FINAL PERFORMANCE EVALUATION

Parameters	Time (Days)	ZS1-1	ZS1-2	ZS1-3	ZS1-C*	ZS1-Mean	ZS1-Stdev	ZS4-1	ZS4-2	ZS4-3	ZS4-C*	ZS4-Mean	ZS4-Stdev
NO ₃ -N (mg/L-N)	0	34.10	33.60	32.55	39.00	33.42	0.79	34.30	34.30	33.10	39.90	33.90	0.69
	7	22.30	22.00	25.10	42.10	23.13	1.71	22.70	21.10	23.30	42.00	22.37	1.14
	14	12.60	14.30	11.80	41.60	12.90	1.28	22.10	23.80	20.10	44.90	22.00	1.85
	21	1.34	0.45	0.42	41.90	0.74	0.52	22.20	23.70	23.00	38.30	22.97	0.75
	28	<0.05	<0.05	<0.05	45.00	<0.05	-	18.00	15.50	16.95	NA	16.82	1.26
	56	<0.05	<0.05	<0.05	38.00	<0.05	-	12.00	15.20	14.10	40.50	13.77	1.63
NO ₂ -N (mg/L-N)	0	0.15	0.15	0.13	0.23	0.14	0.01	0.60	0.57	0.68	0.42	0.62	0.06
	7	0.15	0.58	0.54	0.25	0.42	0.24	8.80	9.06	6.48	0.42	8.11	1.42
	14	4.96	4.06	5.16	0.37	4.73	0.59	4.99	3.57	5.23	0.45	4.60	0.90
	21	7.47	1.74	3.21	0.30	4.14	2.98	3.78	3.28	4.06	0.46	3.71	0.40
	28	<0.05	<0.05	<0.05	<0.05	<0.05	-	<0.05	1.76	<0.05	<0.05	0.62	0.99
	56	<0.05	<0.05	<0.05	<0.05	<0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	-
N ¹⁵ -NH ₄ (mg/L-N)	0	30.70	23.20	25.80	39.70	26.57	3.81	28.50	26.20	28.20	42.10	27.63	1.25
	7	21.20	20.80	22.10	55.10	21.37	0.67	15.90	21.10	19.60	43.40	18.87	2.68
	14	22.20	21.10	18.90	30.50	20.73	1.68	19.30	18.00	14.40	44.10	17.23	2.54
	21	20.70	20.20	21.20	50.50	20.70	0.50	20.30	30.00	18.20	41.40	22.83	6.29
	28	20.00	25.30	22.10	55.70	22.47	2.67	15.80	15.30	15.10	32.10	15.40	0.36
	56	32.30	32.50	32.30	57.20	32.37	0.12	21.10	13.50	7.84	52.80	14.15	6.65
N ¹⁵ -NH ₄ (mg/L-N)	0	1.50	1.20	1.00	1.70	1.23	0.25	1.40	1.20	1.20	1.80	1.27	0.12
	7	1.40	1.60	1.50	1.30	1.50	0.10	0.80	1.00	1.00	1.70	0.93	0.12
	14	1.70	1.80	1.40	1.60	1.63	0.21	1.10	1.10	0.70	2.50	0.97	0.23
	21	1.79	3.24	3.20	1.93	2.74	0.83	1.38	1.59	1.16	1.71	1.38	0.22
	28	2.91	2.79	3.83	2.12	3.18	0.57	1.05	1.06	1.17	1.39	1.09	0.07
	56	6.32	3.54	5.22	2.30	5.03	1.40	1.66	1.19	1.04	2.30	1.30	0.32

* ZS1-C and ZS4-C Are Poisoned Controls

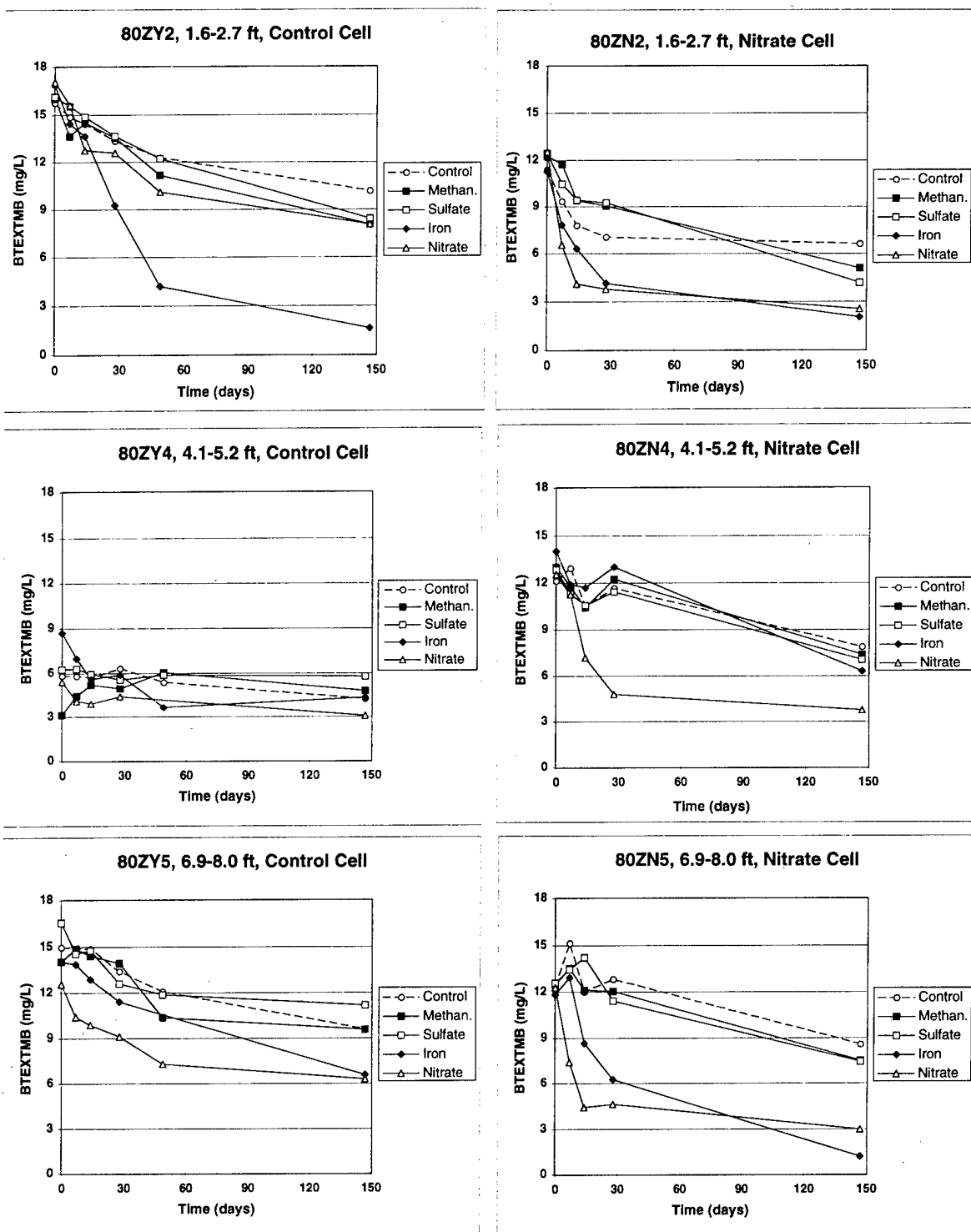
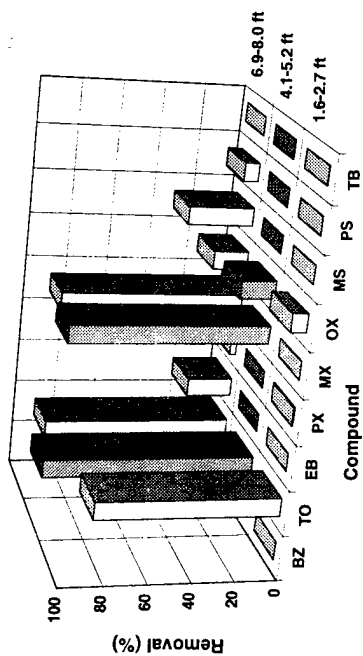


Figure 44. Removal of Combined BTEXTMB in Core Samples from Different Depths in Each Treatment Cell Using Different Electron Acceptors. Mean of Three Replicates Per Set.

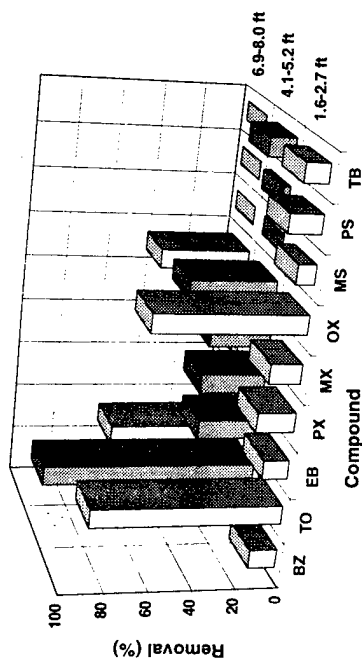
removal under iron-reducing conditions was equal or greater. In contrast, BTEXTMB removal under denitrifying conditions occurred in only the deepest level in the Control Cell, and again the extent of removal under iron-reducing conditions was equivalent. (Figure 43). In the most contaminated interval in the Control Cell (80ZY4), there was no significant removal of BTEXTMB, although the high TPH levels in this core could have caused enhanced sorption and related effects. It is especially interesting that BTEXTMB removal was generally limited to iron-reducing conditions in the upper layer of the Control Cell and occurred under both denitrifying and iron-reducing conditions in the upper layer of the Nitrate Cell (Figure 44). This depth is just below the level sampled by the lysimeters (Section IVD2), and provides supporting evidence that nitrate which was transported to this interval in the Nitrate Cell was being used for biodegradation of BTEXTMB. These data also support the hypothesis that different biological processes are occurring in the different cells. This is further illustrated by the differences in the types of compounds being degraded in each cell under either condition (Figure 45). The most efficient removal of the largest number of compounds occurred in the Nitrate Cell under denitrifying conditions for the first 30-d period, with the highest removals observed for toluene, ethylbenzene, *m*-xylene, and *p*-xylene (Figure 45). In the Control Cell, under iron-reducing conditions, toluene and *o*-xylene were removed to the greatest extent. In other studies, benzene and 1,2,3-trimethylbenzene are generally recalcitrant under denitrifying conditions, and *o*-xylene is often degraded only through cometabolic reactions (Hutchins, 1991a; Jorgensen and Aamand, 1991; Hutchins et al, 1995, Haner et al, 1997). Selected data for the ZY2 and ZN2 cores, however, show that these compounds can be degraded under iron-reducing conditions (Figure 46). For example, there is some benzene removal under iron-reducing conditions in the Control Cell, but not the Nitrate Cell. Of interest, *o*-xylene was completely removed under iron-reducing conditions in both cells, whereas it was more recalcitrant under denitrifying conditions. Also, 1,2,3-trimethylbenzene was degraded in both of these cores under iron-reducing but not nitrate-reducing conditions, although the extent of removal was greatest in the Nitrate Cell (Figure 46).

These data illustrate that iron-reducing activity may have been important in BTEXTMB biodegradation in the Control Cell, and that this activity may have also been expressed in the Nitrate Cell as well. Because equivalent treatability studies were not conducted prior to remediation, it is unknown if iron-reducing activity was actually stimulated by remediation. However, facilitated transport of ammonia nitrogen within both cells may have enhanced microbial activity in general, and this could possibly have benefitted iron reducers as well. The biodegradation of the more recalcitrant alkylbenzenes under iron-reducing conditions indicates that establishment of the combination of iron- and nitrate-reducing conditions may have facilitated BTEXTMB biodegradation in the contaminated sediments. There was generally no observed activity in either the Nitrate Cell or the Control Cell cores under either sulfate-reducing or methanogenic conditions, although in some microcosms BTEXTMB removal was observed for the upper core level in each cell after about 150 days (Figure 44). Toluene and *m*-xylene were the most labile compounds under these more reduced

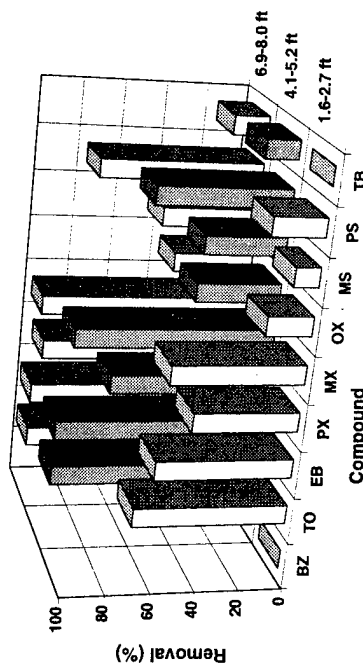
Control Site, Nitrate Addition



Control Site, Iron Addition



Nitrate Cell, Nitrate Added



Nitrate Cell, Iron Added

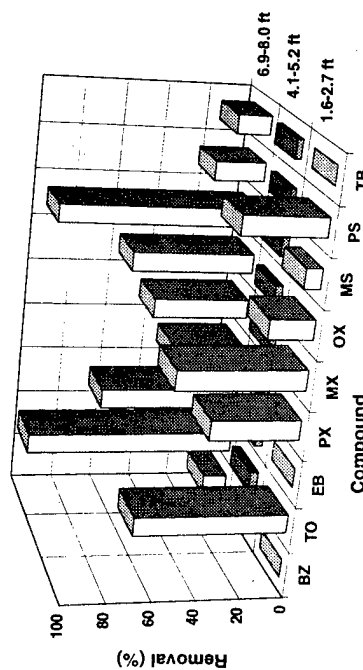


Figure 45. Removal of BTEX/TMB Isomers from Nitrate Cell and Control Cell Cores, With Either Nitrate or Iron Addition. Removals are Shown for First 30 Days of Incubation. Mean of Three Replicates per Set.

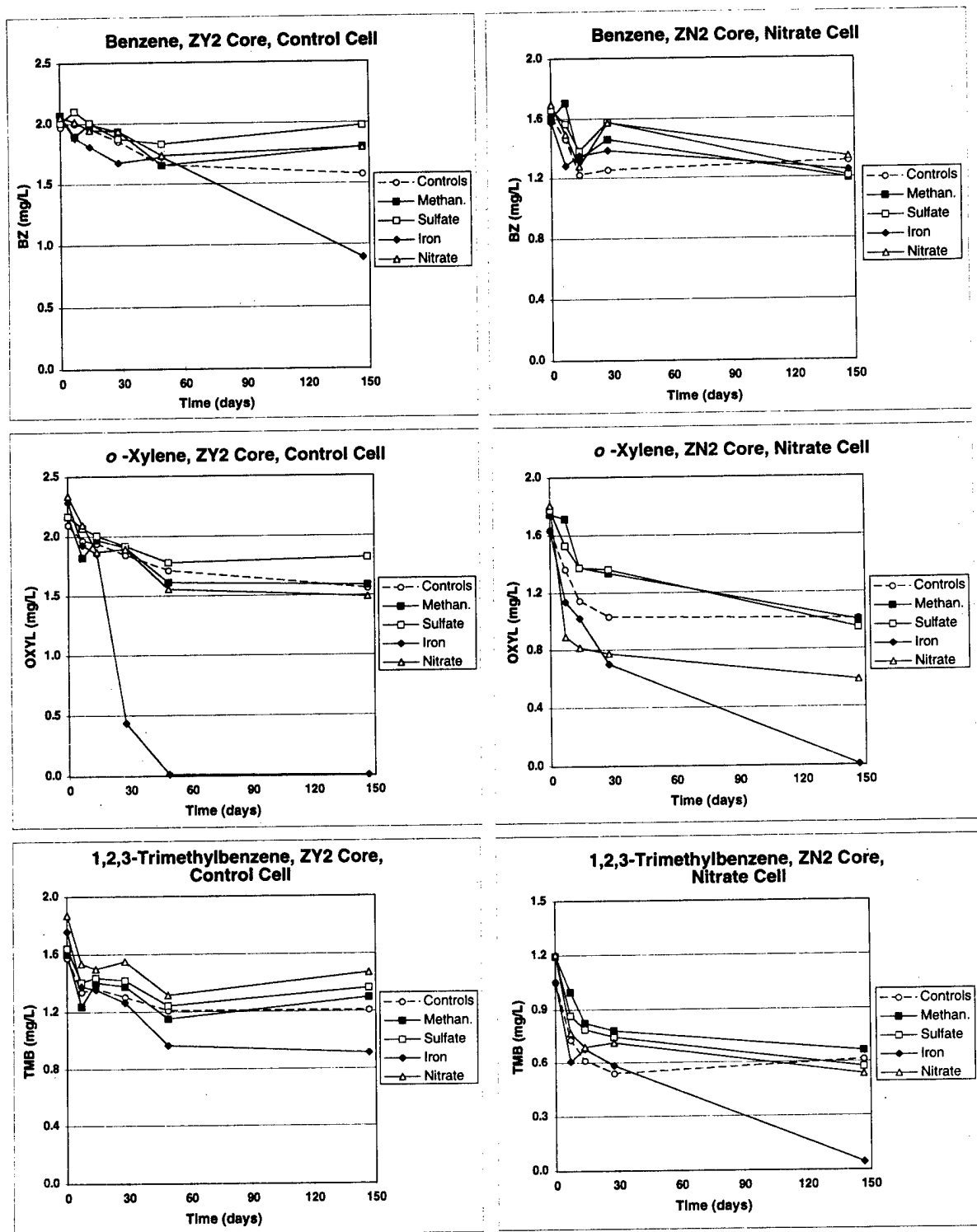


Figure 46. Removal of Benzene, o-Xylene, and 1,2,3-Trimethylbenzene in 80ZY2 and 80ZN2 Cores, Collected 1.6-2.7 ft from Beneath Control and Nitrate Cells, Respectively.

conditions (data not shown). The lack of observed methanogenic or sulfate-reducing activity is disappointing, but not surprising given the relatively short time duration of this test. Because these microbial processes depend more frequently on consortia of populations rather than individual species, longer incubation times are often needed following disturbance of the aquifer core during preparation of microcosms.

4. Mineralization Studies

The preceding microcosm tests focused on removal of BTEXTMB, with biodegradation being inferred through the use of both abiotic and live controls. To verify that removals observed under the various electron acceptor conditions could be attributed at least in part to biodegradation, additional microcosms were prepared at the same time for radiolabel studies. These microcosms were spiked with BTEXTMB as before, except that *m*-[ring-UL-¹⁴C]xylene was added as the test substrate. The microcosms were incubated for 200 days, and were then sacrificed and analyzed as before to determine the distribution of the aqueous radiolabel. Results are shown in Figure 47, and again illustrate that the most robust samples were located in the upper level of each cell. In the Nitrate Cell, mineralization occurred under denitrifying, iron-reducing, sulfate-reducing, and methanogenic conditions in the upper core sample, but only under denitrifying (and, to a lesser extent, iron-reducing) conditions further beneath the Nitrate Cell (Figure 47). In the Control Cell, some mineralization occurred in the upper level under iron-reducing, sulfate-reducing, and methanogenic conditions, but not under nitrate-reducing conditions. This is surprising, given the long incubation time, but it does correlate with the decreased BTEXTMB removal observed under denitrifying conditions at this location compared with the Nitrate Cell (Figure 44). Mineralization of the radiolabeled *m*-xylene occurred predominantly under denitrifying conditions further beneath the Control Cell as well (Figure 47). There was significant mineralization even in the more contaminated 80ZY4 core, which indicates that these microorganisms were metabolically active despite the lack of significant BTEXTMB removal observed previously with this core (Figure 44). These data again show that biodegradation of BTEXTMB in this aquifer could occur under different electron-acceptor conditions, and indicate that contaminant removal probably occurred through a combination of soil washing and bioremediation.

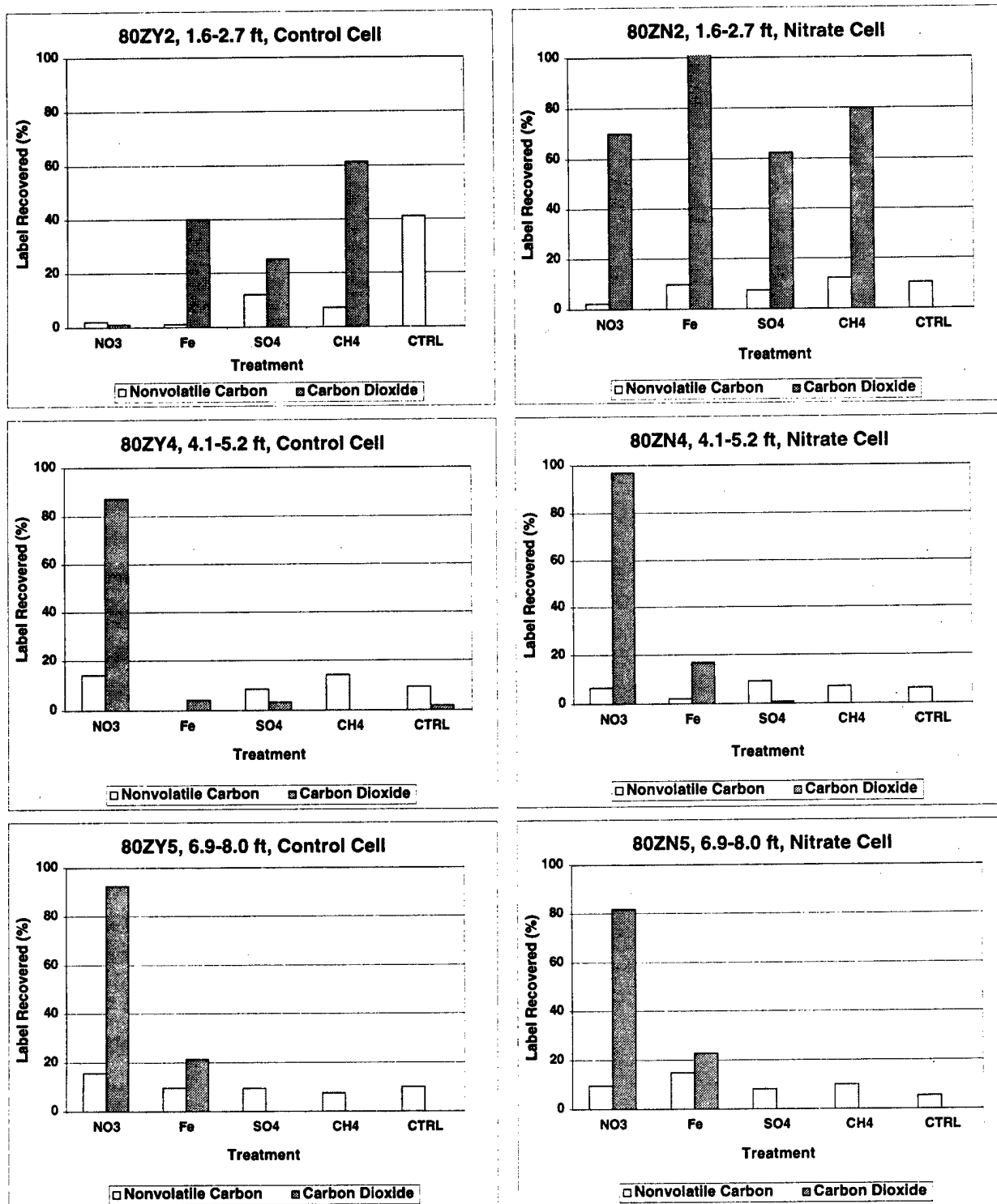


Figure 47. Recovery of Nonvolatile Carbon and Carbon Dioxide from Biodegradation of Radiolabeled m-Xylene in Microcosms from Each Treatment Cell Using Different Electron Acceptors. Mean of 2-3 Replicates, 200 Days.

SECTION V

CONSIDERATIONS FOR FULL-SCALE APPLICATION

The pilot demonstration project was designed to evaluate the extent of bioremediation through sprinkler application of recharge with and without nitrate as an added electron acceptor. Remediation occurred in both cells, in part because of soil washing through continuous application of recharge. In addition, based on collective monitoring well data, core data, and pre- and post-test laboratory treatability studies, bioremediation was most likely occurring in both cells as well. It was not our intent to provide the Control Cell with added electron acceptors; however, the presence of sulfate in the recharge, incorporation of oxygen through sprinkler application, and possible mobilization of solid phase electron acceptors such as bound iron and sulfate species were apparently sufficient to promote bioremediation in this cell, even without nitrate addition. The specific nature of these alternate anaerobic processes, as well as their relative contribution to remedial activity, cannot be quantitated based on the data available. For example, the monitoring well data indicate both methanogenic and sulfate-reducing conditions in the Control Cell, but we cannot prove conclusively that depletion of these electron acceptors was linked to oxidation of the contaminants; in fact, other electron donors could have been involved. From microcosm work with post-test cores, we have shown that iron reduction, methanogenesis, and sulfate reduction were linked to biotransformation of alkylbenzenes and mineralization of *m*-xylene, which demonstrates the potential for these processes in the Control Cell. Again, this does not prove that these processes were operating at that time, and we cannot evaluate the extent of their contribution in the Control Cell. In fact, these same processes were probably also operating in the Nitrate Cell, but perhaps to a lesser extent than denitrification linked to contaminant oxidation. As is often the case with field work, we can look for evidence of these processes, but cannot evaluate their relative contributions without more strict controls, which in turn would lessen the relevance of the work to actual operating conditions.

Regardless of the specific anaerobic process or processes involved, an important aspect of this research is that simple recirculation of recharge, without selected amendments, can still promote bioremediation in fuel-contaminated aquifers. In our study, we cannot assess the relative benefits of indigenous electron acceptors in the recharge versus the mobilization of electron acceptors in the vadose zone. Despite this, the field and laboratory data indicate that it may be advantageous to utilize this approach to promote a variety of anaerobic processes, rather than to try to establish one type of reaction, such as aerobic metabolism or denitrification. In heterogeneous environments, more than one microenvironment conducive to selective reactions is more likely to exist, and establishment of these separate microenvironments should be encouraged rather than controlled. These different environments would encourage biodegradation of compounds which are generally recalcitrant under denitrifying

conditions, such as benzene. Although benzene was not a significant contaminant at this particular site, it may not have been a problem even if it had occurred in higher concentrations within the treatment cells, since it can be degraded under iron-reducing, sulfate-reducing, and methanogenic conditions (Grbic-Galic and Vogel, 1987; Edwards and Grbic-Galic, 1992; Lovely et al, 1996), and these processes occurred in both treatment cells. However, the fate of benzene is an important issue, and it can be a problem at other sites, especially if strictly denitrifying conditions are established.

The pilot demonstration project was not originally designed to evaluate the effects of selected operating parameters. The only operating parameter which was varied was the effective nitrate concentration, and this was increased on two occasions, by: 1) increasing the aqueous nitrate concentration, conducted approximately one-quarter of the way through the demonstration period, and (2) removing the vegetative cover in the stripped plots, conducted approximately halfway through the demonstration period. The effect of both of these operational changes is difficult to measure. In the first case, doubling the influent nitrate concentration was done Jul 15, 1994, and there was little observed effect in the three near-surface cluster wells in the center of the Nitrate Cell (Figure 27). However, this also corresponded to a time of increased rainfall and a subsequent rise of the water table (Figure 17), and so other factors may have been involved. In the second case, sod removal was conducted Nov 14-16, 1994, to evaluate nitrate transport within the stripped plot compared to the rest of the Nitrate Cell. Based on lysimeter studies conducted May 13, 1995, there was indeed enhanced nitrate transport within the stripped plot, and this could be quantified. However, the lysimeter study was done in the spring, and may overestimate the contribution of sod removal during the winter months, when vegetative growth was minimal. In summary, these changes were done to enhance the effective nitrate concentration, but they do not provide a quantitative measure of the response that could be expected for the entire operating period.

Similarly, the effects of other operating parameters can only be theorized, since our intent was not to establish appropriate controls for optimizing system performance. For example, only one type of application scheme was employed, and this was by continuous sprinkler irrigation. Net water usage was 12 million gallons for 20,000 square feet of surface area, over the course of one year. Intermittent sprinkler application would reduce water consumption, but at the expense of maintaining a constant water table mound. For the shallow Eglin water table aquifer, this might not be a problem, since rainfall events have a more pronounced effect on the water table, anyway. In addition, intermittent application might create new flow paths in the vadose zone and enhance access to soil-bound electron acceptors. In fact, it is not known whether periodic oxidation of the vadose zone would facilitate or hinder the mobilization of soil-bound electron acceptors. In addition, switching from continuous to intermittent sprinkler application may result in decreased treatment of regions outside of the treatment cells. One of the limitations of sprinkler application would be that this

creates essentially vertical flow through the contaminated intervals, and zones of low permeability might not be remediated as efficiently. Despite these limitations, the effects of heterogeneity during surface infiltration are not expected to be any greater than those encountered during horizontal flow, as long as the water table is elevated sufficiently to contact the contaminated zones of interest. However, It is not known whether raising the water table to provide better contact within these zones does indeed alleviate this problem, and more work is needed to define the effects of sprinkler placement and vadose zone heterogeneity. The real advantage of surface application is that, for typically thin lenses covering a long or broad area, the recharge will have a shorter flowpath through the contaminated interval, thus maximizing mass transfer of electron acceptors. Clearly, more work is needed in this area to optimize the design application rate, frequency, and spatial orientation.

With respect to application of this technology to other fuel-contaminated sites, several factors need to be evaluated. First and foremost is the location of the fuel, residual saturation, and dissolved contaminants within the subsurface system. Sites with the bulk of contamination residing above the ambient or average water table are more likely to benefit from soil vacuum extraction or aerobic bioventing than with remediation using alternate electron acceptors. In some cases, a combined approach could be used, where dissolved contaminants are dispersed throughout the saturated zones. Sites that contain the bulk of contamination below the water table are not necessarily good candidates for sprinkler application of recharge, especially in heterogeneous aquifers or subsurface systems with thick vadose zones. Although an increased vadose zone might provide more electron acceptors that could be mobilized, consumption of electron acceptors by mineralization of native organic matter may negate this benefit. It is also uncertain how even the distribution of recharge would be after transport through a thick vadose zone. Site heterogeneity will also adversely affect this process, and many sites are quite heterogeneous. However, it is doubtful that the near-surface heterogeneity will be as drastic as that observed with the POL facility at Eglin AFB, where previous tests left behind a myriad of gravel infiltration trenches, open conduits, buried plastic liners, and other artifacts.

Other site-specific problems will include recharge water availability, recharge water quality, land use, and infrastructure. Recirculation of recharge water would be the optimum treatment strategy, but may not be feasible due to either regulatory constraints or, as in the case at Eglin, loss of infiltration capacity through mobilization of colloidal particulates. For anaerobic aquifers, careful attention would be required to prevent oxidation and precipitation of iron and manganese species during recirculation, as well as preventing deleterious interactions with indigenous or added electron acceptors. Sprinkler application would of course not be feasible in areas with substantial land development over the contaminated region, and in drier climates where water loss through evaporation would make costs prohibitive. The field demonstration project clearly showed the benefit of removing surface vegetation for enhanced nitrate transport, and this option should be considered even when utilizing

mixed electron acceptors or solubilizing soil-bound electron acceptors. Although removal of vegetative cover does incur an initial capital cost, the costs may not be significant, depending on current land usage. For example, where the cover consists primarily of grasses, relocation of the removed cover to other areas can provide a net benefit, and reseedling can be done to reestablish the cover once the project is complete. The use of herbicides should also be investigated; herbicides were not chosen as a maintenance option in this project because: (1) the effect of the herbicides on the microbial populations that degrade alkylbenzenes under denitrifying conditions was unknown, and (2) death and decay of the vegetation might have contributed an increased organic load which would compete with the contaminants for electron donor capacity. Although it may seem intuitive to remove surface vegetation prior to initiating remediation, this may not be the best strategy. Plant growth promotes microbial diversity within the rhizosphere, and higher denitrifier counts have been observed in soil systems with root structures (J. Schnoor, personal communication). One strategy might therefore be to prime the system by applying nitrate to vegetated surfaces initially, promote the growth and development of a robust denitrifier community, and then remove the vegetative cover and initiate high rate infiltration to transport bacteria to the deeper contaminated zones. More work is needed to evaluate the optimum strategy for reducing electron acceptor demand in the rhizosphere and vadose zones.

The time required for remediation to a specified regulatory endpoint using this process cannot be determined from the current pilot demonstration project. As stated previously, site heterogeneity precluded a direct and accurate comparison of mass contaminant levels between the time of the initial site characterization and the Interim Performance Evaluation. Based on core data from the Interim and Final Performance Evaluations, operation of the pilot demonstration project resulted in a BTEXTMB mass reduction of $66 \pm 1\%$ in both treatment cells, equivalent to a mass loss of 106 kg and 21 kg in the Nitrate Cell and Control Cell, respectively, following eight months of treatment. JP-4 decreased by 37% (2170 kg) in the Nitrate Cell and increased by 11% (210 kg) in the Control Cell during this same time interval. It is important to note that the previous study using hydrogen peroxide resulted in lower mass ratios of BTEXTMB in the contaminated sediments than expected for these types of spills, and hence more time may have been required had this site not already undergone partial remediation. Alternately, the observed mass reductions may have been increased if the entire vegetative surface had been stripped, facilitating nitrate transport to the contaminated intervals. Because nitrate distribution was uneven, the mass flux of nitrate to the contaminated intervals is unknown, and hence cannot be correlated to the rate of remediation. Water quality data alone are inadequate to predict the rate of remediation, because of the fluctuating water table and mass transport limitations that obscure the actual mass reduction in the aquifer solids. In addition, core samples were taken only three times during the project, and this proved insufficient to establish a rate expression for remediation. Modeling exercises are in progress and will provide some insight, but the validity of such predictions has not been established under these operating conditions, and certainly would not reflect the rate of remediation to be

expected if this process were conducted under ideal operating conditions.

The pilot demonstration project was invaluable in demonstrating remediation under mixed electron acceptor conditions, and in determining some of the controlling parameters. However, to provide an assessment of economic feasibility, nitrate distribution would first have to be uniform so that valid cost information can be derived and correlated back to mass reduction for several time intervals. Based on the potential shown here for mixed anaerobic processes, combined with the uncertainties regarding the effects of process operating variables, this approach should be investigated more fully at bench and pilot scale prior to utilization for remedial activities.

SECTION VI

CONCLUSIONS

The main objective of this project was to conduct a thorough and quantitative demonstration of the benefits of using nitrate as an alternate electron acceptor. Although this project represents a well-characterized study with extensive site characterization and monitoring, it is difficult to quantitatively evaluate the success of nitrate-based bioremediation because of three factors: (1) due to biological processes in the rhizosphere, nitrate was not uniformly and consistently delivered to the contaminated interval, (2) other biological processes in the Control Cell allowed bioremediation to proceed there as well as in the Nitrate Cell, and (3) near-surface site heterogeneities did not allow for even distribution of recharge and complicated the performance evaluation based on random core samples. Despite these problems, the pilot demonstration project demonstrated the efficacy of *in situ* bioremediation with alternate electron acceptors, and provided good evidence for nitrate-based bioremediation. The most relevant conclusions can be summarized as follows:

1. Sprinkler application was an efficient mechanism for transporting recharge through the contaminated interval, despite the selective removal of nitrate in the rhizosphere. Tracer studies, microbial counts, and treatability studies all show that recharge can penetrate through the contaminated interval over a large area, and therefore this method should be considered for relatively thin lenses (< 10 ft) of contamination in these cases.

2. Nitrate application by sprinkler recharge is compromised by vegetative cover, both due to uptake of the nutrient by the vegetation and the concomitant utilization of nitrate (and sulfate) during anaerobic decay of organic matter in the rhizosphere. Stripping of the vegetative cover, followed by the use of weed barriers to prevent regrowth, is an effective mechanism for overcoming this problem. This permits high rates of nitrate transport and reduces soluble organic carbon levels. However, additional studies are needed to determine whether stimulation and growth of the vegetative cover could enhance microbial diversity in the rhizosphere, leading to greater metabolic potential as bacteria are transported to the contaminated zones.

3. Recharge application had a positive effect in both cells, resulting in decreased contaminant loads, increased nutrient distribution, increased microbial populations, and decreased sediment toxicity. Based on core data from the Interim and Final Performance Evaluations, BTEXTMB was reduced by $66 \pm 1\%$ in both treatment cells, equivalent to a mass loss of 106 kg and 21 kg in the in the Nitrate Cell and Control Cell, respectively. In contrast, JP-4 decreased by 37% (2170 kg) in the Nitrate Cell and increased by 11% (210 kg) in the Control Cell.

4. Removal of the vegetative cover facilitated nitrate transport in the Nitrate Cell, which accelerated contaminant removal relative to the corresponding Control Cell. There was higher fractional contaminant mass removal of many of the isomers in the Nitrate Cell stripped plot compared to the Control Cell stripped plot. Core and water quality data show that mesitylene, which is labile under denitrifying conditions, was removed to a greater extent in the Nitrate Cell than in the Control Cell.

5. Bioremediation was stimulated in both treatment cells through the provision of additional and alternate electron acceptors to the contaminated intervals. Although nitrate was added to the sprinkler recharge for the Nitrate Cell, the recharge also contains sulfate, which was used more extensively in the Control Cell. It is likely that sulfate would have been used to the same extent in the Nitrate Cell if nitrate had not been added. Sprinkler application also incorporates oxygen into the recharge, and the resulting soil washing solubilizes additional sulfate which becomes available for *in situ* bioremediation. One consequence of remediation was increased ammonia nitrogen levels in both cells, which could enhance microbial activity in general.

6. Based on monitoring well information and the post-test core data and treatability studies, different microbial processes were occurring to various extents in the different treatment cells. Monitoring well data provided evidence of sulfate reduction in the Control Cell, but not in the Nitrate Cell. In addition, short-term post-test treatability studies demonstrated active BTEXTMB removal in the upper zone of the Nitrate Cell under both denitrifying and iron-reducing conditions. However, BTEXTMB removal occurred only under iron-reducing conditions in the corresponding upper zone of the Control Cell. Long-term treatability studies conducted with post-test core material from selected zones in both cells demonstrated removal of alkylbenzenes and mineralization of *m*-xylene under denitrifying, iron-reducing, sulfate-reducing, and/or methanogenic conditions.

Monitoring well data, geoprobe data, core data, and treatability studies all substantiate the occurrence of *in situ* bioremediation in both treatment cells. Due to the presence of site heterogeneity and the occurrence of bioremediation in the Control Cell, the relative contribution of biodegradation to BTEXTMB removal cannot be accurately determined. Modeling exercises are in progress and initial results indicate that biodegradation was a significant process in contaminant reduction in both treatment cells (Ouyang et al, 1997). These data collectively indicate that biotic processes related to BTEXTMB removal were occurring in both treatment cells, although to various extents in the different regions. Considering that the Nitrate Cell had approximately five times the BTEXTMB contaminant mass initially than the Control Cell, and the fractional removal of BTEXTMB in the stripped plot of the Nitrate Cell was also higher than that of the Control Cell, it is reasonable to conclude that the addition of nitrate as a supplemental electron acceptor provided greater mass removal of BTEXTMB through biodegradation.

SECTION VII

RECOMMENDATIONS

To derive the answers to satisfy the original objectives, this project should be repeated at a smaller scale to better control site heterogeneity and facilitate nitrate transport to the subsurface. However, performance of the pilot project was good, and demonstrated that subsurface microbial activity could be stimulated through sprinkler application of recharge containing natural as well as added electron acceptors. This approach should be investigated at field scale with a more homogeneous aquifer using multiple electron acceptors to enhance anaerobic bioremediation. Specific recommendations are as follow:

1. Sprinkler application should be considered as an alternative strategy to vapor extraction or bioventing treatment strategies for *in situ* bioremediation of fuel-contaminated aquifers which contain much of the contamination within the saturated zone. This would avoid the use of extraction wells and take advantage of natural electron acceptors in the soil vadose zone as well as added electron acceptors. This of course would be dependent on a steady source of available recharge. However, design of a surface application system does require significant characterization of site hydrogeology as well as a quantitative understanding of site specific infiltration and water table mounding characteristics. In addition, even surface distribution of sprinkler recharge is required not only to build the water table mound, but to avoid "dead zones" of stagnant subsurface water which counteract overall efficiency of remediation. Recirculation of ground water would be recommended for those cases where it can be demonstrated that this would not result in aquifer plugging. However, recirculation of ground water will most likely have to undergo more review for approval and permitting due to the reinjection of contaminated ground water. Still, in cases where ground water can not be recovered, much greater care will be required to ensure that downgradient receptors are not impacted, and therefore these systems should be operated with ground water capture and recirculation or treatment and disposal whenever possible.

2. This project has demonstrated that different microbial processes can be stimulated with different electron acceptors in the recharge water. However, the optimum combination of electron acceptors is unknown, as well as are the effects on specific contaminants. Benzene was at low concentrations in this weathered material, and so the effects of iron-, sulfate-, and nitrate-reducing conditions on benzene biodegradation in the field could not be determined in this study. Combinations of multiple electron acceptors should be tested in complex soil systems such as this to determine optimum combinations for the removal of selected contaminants. Secondary effects, such as production of ammonia-nitrogen as a nutrient through dissimilatory nitrate reduction, should also be considered.

3. Future studies should incorporate several clustered downgradient wells and incorporate multiple tracers to better define the contribution of biodegradation to the overall removal process. Modeling in this project is limited to the immediate area of the treatment cells, but it is possible that mobilized electron acceptors contributed to bioremediation of solubilized contaminants downgradient of the treatment cells. If this is true, the contribution of bioremediation is being underestimated, and the efficacy of using this type of "one-pass" system, rather than recirculation of contaminated ground water, is not being realized. Again, however, caution must be used to avoid contamination of downgradient wells. One acceptable scenario would be to pump and either recirculate or treat and dispose the ground water resulting from the recharge, but to construct recovery wells sufficiently far downgradient to take advantage of the increased residence time.

SECTION VIII

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APPENDIX A GC/MS DATA FOR EGLIN AFB SOIL CORES

Sample ID	Date	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bot int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80A7	Mar-93	0.2	0.5	10.9	10.6	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80A6	Mar-93	0.5	1.0	10.6	10.1	0.5	<0.001	0.005	<0.001	0.003	0.004	0.005	<0.001	<0.001	<0.001	0.018	<10.0
80A5	Mar-93	1.0	1.5	10.1	9.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80A4	Mar-93	1.5	2.0	9.6	9.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	0.022	297.0
80A3	Mar-93	2.0	2.5	9.1	8.6	0.5	<0.001	<0.001	<0.001	0.008	<0.001	<0.001	<0.001	0.008	<0.001	0.007	235.0
80A2	Mar-93	2.5	3.0	8.6	8.1	0.5	0.002	<0.001	<0.001	<0.001	<0.001	0.002	0.002	<0.001	0.025	0.149	145.0
80A1	Mar-93	3.0	3.5	8.1	7.6	0.5	0.004	<0.001	0.004	0.015	0.020	<0.001	0.062	18.000	5.990	56.084	921.0
80A13	Mar-93	3.5	3.8	7.6	7.3	0.3	0.025	0.014	2.120	6.870	15.400	0.005	7.660	9.730	3.350	29.555	1850.0
80A12	Mar-93	3.8	4.3	7.3	6.8	0.5	0.037	0.002	1.140	3.470	7.710	0.007	4.110	6.550	2.200	20.401	1000.0
80A11	Mar-93	4.3	4.8	6.8	6.3	0.5	0.021	<0.001	0.847	2.490	5.580	0.003	2.710	0.060	0.023	0.168	<10.0
80A10	Mar-93	4.8	5.3	6.3	5.8	0.5	0.004	0.004	0.005	0.012	0.025	<0.001	0.034	0.035	0.008	0.096	<10.0
80A9	Mar-93	5.3	5.9	5.8	5.2	0.6	0.003	<0.001	0.006	0.016	0.018	<0.001	0.009	0.013	0.004	0.034	<10.0
80A8	Mar-93	5.9	6.5	5.2	4.6	0.6	<0.001	<0.001	0.002	0.006	0.005	<0.001	0.002	0.021	0.006	0.113	<10.0
80A19	Mar-93	6.5	7.0	4.6	4.1	0.5	0.003	<0.001	0.015	0.021	0.043	<0.001	0.004	0.029	0.008	0.193	<10.0
80A18	Mar-93	7.0	7.6	4.1	3.5	0.6	0.007	<0.001	0.028	0.035	0.081	<0.001	0.005	0.029	0.008	0.195	<10.0
80A17	Mar-93	7.6	8.2	3.5	2.9	0.6	0.003	<0.001	0.029	0.036	0.084	<0.001	0.005	0.024	0.007	0.159	<10.0
80A16	Mar-93	8.8	8.8	2.9	2.3	0.6	0.005	<0.001	0.023	0.029	0.068	<0.001	0.004	0.024	0.003	0.157	<10.0
80A15	Mar-93	9.4	9.4	2.3	1.7	0.6	0.004	<0.001	0.023	0.021	0.072	<0.001	0.005	0.024	<0.001	0.063	<10.0
80A14	Mar-93	10.0	10.5	1.1	0.6	0.5	0.006	<0.001	0.009	0.004	0.020	<0.001	0.003	0.018	<0.001	0.033	<10.0
80B6	Mar-93	<0.001	0.5	10.9	10.4	0.5	0.007	0.005	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	0.015	<10.0
80B5	Mar-93	0.5	1.0	10.4	9.9	0.5	0.005	0.006	<0.001	0.005	0.008	0.009	0.003	0.004	<0.001	0.040	<10.0
80B4	Mar-93	1.0	1.5	9.9	9.4	0.5	0.018	0.009	<0.001	0.004	0.007	0.006	<0.001	0.003	<0.001	0.048	<10.0
80B3	Mar-93	1.5	1.9	9.4	9.0	0.4	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<10.0
80B2	Mar-93	1.9	2.3	9.0	8.6	0.4	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<10.0
80B1	Mar-93	2.3	2.7	8.6	8.2	0.4	0.001	0.006	0.002	0.008	<0.001	0.001	0.018	0.391	0.006	0.044	400.0
80B12	Mar-93	2.7	3.0	8.2	7.9	0.3	0.001	0.028	0.005	0.016	0.009	0.005	0.115	0.81	0.081	0.650	388.0
80B11	Mar-93	3.0	3.5	7.9	7.4	0.5	<0.001	0.050	0.009	0.023	0.017	0.008	0.212	0.781	0.156	1.257	375.0
80B10	Mar-93	3.5	4.0	7.4	6.9	0.5	0.001	0.004	0.004	0.005	0.009	<0.001	0.047	0.160	0.024	0.254	27.1
80B9	Mar-93	4.0	4.5	6.9	6.4	0.5	<0.001	0.002	0.010	0.015	0.030	<0.001	0.021	0.071	0.014	0.163	11.0
80B8	Mar-93	4.5	5.0	6.4	5.9	0.5	0.006	0.002	0.028	0.039	0.079	<0.001	0.026	0.068	0.023	0.289	<10.0
80B7	Mar-93	5.0	5.5	5.9	5.4	0.5	0.002	<0.001	0.024	0.034	0.069	<0.001	0.021	0.072	0.018	0.240	10.7
80B19	Mar-93	5.5	6.0	5.4	4.9	0.5	0.004	<0.001	0.005	0.007	0.013	<0.001	0.003	0.012	0.003	0.046	<10.0
80B18	Mar-93	6.0	6.5	4.9	4.4	0.5	<0.001	<0.001	0.008	0.010	0.003	<0.001	0.002	0.014	0.002	0.038	<10.0
80B17	Mar-93	6.5	7.0	4.4	3.9	0.5	<0.001	<0.001	0.007	0.009	0.009	<0.001	0.003	0.012	<0.001	0.040	<10.0
80B16	Mar-93	7.0	7.4	3.9	3.5	0.4	<0.001	<0.001	0.002	0.002	0.002	<0.001	<0.001	0.006	<0.001	0.013	<10.0
80B15	Mar-93	7.4	7.8	3.5	3.1	0.4	<0.001	<0.001	0.014	0.006	<0.001	<0.001	<0.001	0.026	<0.001	0.046	<10.0
80B14	Mar-93	8.2	8.6	3.1	2.7	0.4	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.008	<0.001	0.011	<10.0
80B13	Mar-93	8.6	9.0	2.3	1.9	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.014	<0.001	0.014	<10.0
80B23	Mar-93	9.0	9.6	1.9	1.3	0.6	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.011	<0.001	0.012	<10.0
80B22	Mar-93	9.6	10.2	1.3	0.7	0.6	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.008	<0.001	0.010	<10.0
80B21	Mar-93	10.2	10.8	0.7	0.1	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.014	<0.001	0.014	<10.0
80B20	Mar-93	10.8	11.4	0.1	-0.5	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.017	<0.001	0.017	<10.0
80C7	Mar-93	11.4	12.0	-0.5	-1.1	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.013	<0.001	0.013	<10.0
80C6	Mar-93	2.5	3.0	9.5	9.0	0.5	<0.001	0.013	0.004	0.005	0.005	0.009	0.003	0.003	0.008	0.051	198.0
		3.0	3.5	9.0	8.5	0.5	<0.001	<0.001	<0.001	0.007	0.008	<0.001	<0.001	0.003	0.006	0.024	206.0

APPENDIX A (cont.) **GC/MS DATA FOR EGLIN AFB SOIL CORES**

Sample ID	Date	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bot int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80C5	Mar-93	3.5	4.0	8.5	8.0	0.5	<0.001	0.006	0.004	0.008	<0.001	0.020	0.095	<0.001	0.551	0.684	721.0
80C4	Mar-93	4.5	4.5	8.0	7.5	0.5	<0.001	0.005	0.009	0.122	0.149	0.178	6.200	4.070	3.510	14.243	3310.0
80C3	Mar-93	4.5	5.0	7.5	7.0	0.5	<0.001	0.004	0.021	0.216	0.380	0.241	3.830	7.690	3.370	15.752	926.0
80C2	Mar-93	5.0	5.5	7.0	6.5	0.5	<0.001	<0.001	0.001	0.012	0.022	0.012	0.105	0.300	0.111	0.563	23.4
80C1	Mar-93	5.5	6.0	6.5	6.0	0.5	<0.001	<0.001	<0.001	0.002	0.003	0.004	0.065	0.132	0.067	0.273	12.1
80C15	Mar-93	6.0	6.5	6.0	5.5	0.5	0.002	0.006	0.005	0.011	0.024	0.004	0.045	0.102	0.046	0.244	11.6
80C14	Mar-93	6.5	7.0	5.5	5.0	0.5	<0.001	<0.001	0.003	0.006	0.012	<0.001	0.020	0.057	0.022	0.120	<10.0
80C13	Mar-93	7.0	7.5	5.0	4.5	0.5	<0.001	<0.001	0.004	0.015	0.028	<0.001	0.030	0.109	0.036	0.223	<10.0
80C12	Mar-93	7.5	7.9	4.5	4.1	0.4	<0.001	<0.001	0.004	0.013	0.023	<0.001	0.022	0.098	0.030	0.189	<10.0
80C11	Mar-93	7.9	8.3	4.1	3.7	0.4	0.003	<0.001	0.008	0.019	0.038	<0.001	0.022	0.089	0.026	0.204	<10.0
80C10	Mar-93	8.3	8.7	3.7	3.3	0.4	0.002	<0.001	0.062	0.015	0.030	<0.001	0.019	0.085	0.030	0.243	<10.0
80C9	Mar-93	8.7	9.1	3.3	2.9	0.4	<0.001	<0.001	0.002	0.010	0.017	<0.001	0.024	0.092	0.035	0.180	<10.0
80C8	Mar-93	9.1	9.5	2.9	2.5	0.4	<0.001	<0.001	0.002	0.011	0.016	<0.001	0.027	0.097	0.036	0.189	<10.0
80D4	Mar-93	1.0	1.6	11.3	10.7	0.6	<0.001	0.005	<0.001	<0.001	0.004	0.004	<0.001	<0.001	<0.001	0.014	13.8
80D3	Mar-93	1.6	2.2	10.7	10.1	0.6	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	<10.0
80D2	Mar-93	2.2	2.8	10.1	9.5	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	10.1
80D1	Mar-93	2.8	3.4	9.5	8.9	0.6	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<10.0
80D12	Mar-93	3.4	4.2	8.9	8.1	0.8	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	0.037	0.398	0.053	0.476	299.0
80D11	Mar-93	4.2	4.7	8.1	7.6	0.5	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	0.796	0.105	0.946	595.0
80D10	Mar-93	4.7	5.2	7.6	7.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	0.070	0.013	0.090	67.1
80D9	Mar-93	5.2	5.7	7.1	6.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.050	0.009	0.062	61.6
80D8	Mar-93	6.2	6.7	6.6	6.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.056	0.019	0.075	80.3
80D7	Mar-93	6.7	7.2	6.1	5.6	0.5	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.029	0.007	0.038	54.3
80D6	Mar-93	7.2	7.6	5.1	4.7	0.4	<0.001	<0.001	0.006	0.010	0.021	<0.001	0.005	0.023	0.006	0.072	<10.0
80D5	Mar-93	7.6	8.0	4.7	4.3	0.4	<0.001	<0.001	0.012	0.019	0.038	0.005	0.008	0.035	0.010	0.126	<10.0
80D18	Mar-93	8.0	8.3	4.3	4.0	0.3	<0.001	0.006	0.113	0.021	0.048	0.030	0.039	0.016	0.007	0.143	<10.0
80D17	Mar-93	8.3	8.8	4.0	3.5	0.5	0.008	0.051	0.113	0.199	0.484	0.331	0.041	0.159	0.065	1.449	<10.0
80D16	Mar-93	8.8	9.3	3.5	3.0	0.5	<0.001	0.075	0.135	0.226	0.559	0.420	0.041	0.164	0.089	1.689	<10.0
80D15	Mar-93	9.3	9.8	3.0	2.5	0.5	<0.001	0.066	0.113	0.191	0.460	0.366	0.033	0.138	0.057	1.424	<10.0
80D14	Mar-93	9.8	10.4	2.5	1.9	0.6	<0.001	0.052	0.183	0.247	0.647	0.206	0.032	0.152	0.061	1.581	<10.0
80D13	Mar-93	10.4	11.0	1.9	1.3	0.6	<0.001	0.028	0.156	0.197	0.511	0.076	0.023	0.121	0.048	1.160	<10.0
80 E7	Mar-93	1.1	1.5	11.2	10.8	0.4	0.003	0.011	0.072	0.013	0.025	0.010	<0.001	0.007	0.003	0.144	<10.0
80 E6	Mar-93	1.5	2.0	10.8	10.3	0.5	<0.001	0.003	0.003	0.005	0.012	0.004	0.003	0.006	0.003	0.038	<10.0
80 E5	Mar-93	2.0	2.5	10.3	9.8	0.5	0.004	0.009	0.008	0.012	0.026	0.008	<0.001	0.008	<0.001	0.075	<10.0
80 E4	Mar-93	2.5	3.0	9.8	9.3	0.5	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.002	25.8
80 E3	Mar-93	3.0	3.5	9.3	8.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.052	<0.001	0.052	542.0
80 E2	Mar-93	3.5	4.0	8.8	8.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.056	<0.001	0.006	0.062	849.0
80 E1	Mar-93	4.0	4.5	8.3	7.8	0.5	<0.001	0.021	0.085	0.174	0.367	0.110	5.380	1.370	1.090	8.597	2880.0
80 E15	Mar-93	4.5	4.7	7.8	7.6	0.2	0.002	0.068	11.200	16.900	45.200	11.000	7.700	24.200	6.020	122.290	3270.0
80 E14	Mar-93	4.7	5.1	7.6	7.2	0.4	0.001	0.016	0.983	1.330	3.680	0.955	0.520	1.690	0.468	9.643	213.0
80 E13	Mar-93	5.1	5.6	7.2	6.7	0.5	0.003	0.012	0.207	0.238	0.680	0.112	0.052	0.213	0.072	1.690	15.4
80 E12	Mar-93	5.6	6.0	6.7	6.3	0.4	0.032	0.003	0.197	0.208	0.415	<0.001	0.310	0.176	0.045	1.386	<10.0
80 E11	Mar-93	6.0	6.5	6.3	5.8	0.5	0.023	<0.001	0.132	0.113	0.127	<0.001	0.015	0.158	0.008	0.576	<10.0
80 E10	Mar-93	6.5	7.0	5.8	5.3	0.5	0.029	<0.001	0.095	0.054	0.201	<0.001	0.013	0.160	0.008	0.560	<10.0
80 E9	Mar-93	7.0	7.5	5.3	4.8	0.5	0.043	0.002	0.166	0.153	0.228	<0.001	0.017	0.232	0.015	0.856	<10.0
80 E8	Mar-93	7.5	8.0	4.8	4.3	0.5	0.028	0.001	0.110	0.132	0.141	0.009	0.024	0.239	0.016	0.701	10.4
80 E23	Mar-93	8.0	8.4	4.3	3.9	0.4	0.020	<0.001	0.059	0.123	0.012	0.002	0.003	0.148	0.003	0.368	<10.0

APPENDIX A (cont.) **GC/MS DATA FOR EGLIN AFB SOIL CORES**

Sample ID	Date	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bot int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB: TPH (as JP-4) (mg/kg)
80 E22	Mar-93	8.4	8.8	3.9	3.5	0.4	0.015	0.002	0.041	0.116	<0.001	<0.001	<0.001	0.133	<0.001	0.308
80 E21	Mar-93	8.8	9.2	3.5	3.1	0.4	0.011	0.002	0.021	0.048	0.007	0.003	<0.001	0.134	<0.001	0.227
80 E20	Mar-93	9.2	9.6	3.1	2.7	0.4	0.006	<0.001	0.004	0.004	<0.001	<0.001	<0.001	0.094	<0.001	0.107
80 E19	Mar-93	9.6	10.0	2.7	2.3	0.4	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.077	<0.001	0.080
80 E18	Mar-93	10.0	10.4	2.3	1.9	0.4	0.004	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.085	<0.001	0.090
80 E17	Mar-93	10.4	10.8	1.9	1.5	0.4	0.002	<0.001	0.002	0.007	<0.001	<0.001	<0.001	0.042	<0.001	0.053
80 E16	Mar-93	10.8	11.2	1.5	1.1	0.4	<0.001	0.002	0.002	0.016	<0.001	<0.001	<0.001	0.015	<0.001	0.036
80F7	Mar-93	2.0	2.5	11.4	10.9	0.5	0.003	0.028	0.005	0.008	0.017	0.009	<0.001	0.005	<0.001	0.075
80F6	Mar-93	2.5	3.0	10.9	10.4	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
80F5	Mar-93	3.0	3.5	10.4	9.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
80F4	Mar-93	3.5	4.0	9.9	9.4	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
80F3	Mar-93	4.0	4.4	9.4	9.0	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
80F2	Mar-93	4.4	4.8	9.0	8.6	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.037	<0.001	0.035	0.093
80F1	Mar-93	4.8	5.2	8.6	8.2	0.4	<0.001	0.020	0.001	0.081	0.038	2.620	4.370	3.100	3.100	10.277
80F15	Mar-93	5.2	5.5	8.2	7.9	0.3	0.001	0.250	2.846	5.390	11.819	10.560	6.755	10.423	5.365	53.410
80F14	Mar-93	5.5	6.0	7.9	7.4	0.5	0.003	0.481	5.690	10.700	23.600	18.500	9.140	20.800	7.630	2610.0
80F13	Mar-93	6.0	6.5	7.4	6.9	0.5	<0.001	0.028	0.135	0.198	0.487	0.363	0.049	0.188	0.061	96.544
80F12	Mar-93	6.5	7.0	6.9	6.4	0.5	<0.001	0.020	0.139	0.215	0.537	0.372	0.060	0.229	0.071	10.6
80F11	Mar-93	7.0	7.4	6.4	6.0	0.4	<0.001	0.025	0.129	0.209	0.517	0.357	0.053	0.254	0.059	1.643
80F10	Mar-93	7.4	7.8	6.0	5.6	0.4	<0.001	0.035	0.127	0.183	0.480	0.348	0.032	0.147	0.040	1.602
80F9	Mar-93	7.8	8.2	5.6	5.2	0.4	<0.001	0.014	0.064	0.106	0.243	0.176	0.013	0.071	0.025	1.392
80G7	Mar-93	3.0	3.5	10.0	9.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.072
80G6	Mar-93	3.5	4.0	9.5	9.0	0.5	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.060
80G5	Mar-93	4.0	4.5	9.0	8.5	0.5	0.005	0.033	0.004	0.203	0.180	1.400	1.540	0.086	<0.001	<0.001
80G4	Mar-93	4.5	5.0	8.5	8.0	0.5	<0.001	0.251	0.231	6.560	6.590	24.300	21.400	8.810	9.380	5.471
80G3	Mar-93	5.0	5.5	8.0	7.5	0.5	<0.001	0.271	1.840	13.800	23.000	27.800	15.100	29.800	11.800	2020.0
80G2	Mar-93	5.5	6.0	7.5	7.0	0.5	<0.001	0.030	0.124	0.496	1.100	1.020	0.269	0.916	0.285	77.522
80G1	Mar-93	6.0	6.5	7.0	6.5	0.5	<0.001	0.064	0.114	0.269	0.685	0.564	0.108	0.393	0.122	123.411
80G15	Mar-93	6.5	6.9	6.5	6.1	0.4	<0.001	0.503	0.452	0.939	2.190	1.640	0.483	1.370	0.441	4.240
80G14	Mar-93	6.9	7.3	6.1	5.7	0.4	<0.001	0.298	0.192	0.348	0.842	0.636	0.184	0.483	0.129	8.018
80G13	Mar-93	7.3	7.8	5.7	5.2	0.5	<0.001	0.074	0.089	0.137	0.292	0.198	0.111	0.246	0.052	3.112
80G12	Mar-93	7.8	8.3	5.2	4.7	0.5	<0.001	<0.001	0.005	0.009	0.018	0.005	0.018	0.019	0.003	1.200
80G11	Mar-93	8.3	8.8	4.7	4.2	0.5	<0.001	<0.001	0.012	0.029	0.079	<0.001	0.017	0.012	0.003	0.075
80G10	Mar-93	8.8	9.3	4.2	3.7	0.5	<0.001	<0.001	0.022	0.067	0.179	0.003	0.010	0.020	0.012	0.151
80G9	Mar-93	9.3	9.8	3.7	3.2	0.5	<0.001	<0.001	0.023	0.111	0.292	0.015	0.040	0.068	0.038	0.312
80G8	Mar-93	9.8	10.0	3.2	3.0	0.2	<0.001	<0.001	0.012	0.093	0.247	0.010	0.039	0.070	0.038	0.508
80H6	Mar-93	3.0	3.5	9.5	9.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
80H5	Mar-93	3.5	4.0	9.0	8.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
80H4	Mar-93	4.0	4.5	8.5	8.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
80H3	Mar-93	4.5	5.0	8.0	7.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
80H2	Mar-93	5.0	5.5	7.5	7.0	0.5	<0.001	0.001	<0.001	0.004	0.008	0.002	0.031	0.050	0.019	0.115
80H1	Mar-93	5.5	6.0	7.0	6.5	0.5	<0.001	<0.001	<0.001	0.010	0.021	0.015	0.042	0.077	0.038	0.203
80H14	Mar-93	6.0	6.2	6.5	6.3	0.2	<0.001	0.003	0.002	0.006	0.011	0.005	0.033	0.052	0.019	0.131
80H13	Mar-93	6.2	6.6	6.3	5.9	0.4	<0.001	0.003	0.006	0.008	0.016	0.005	0.018	0.052	0.018	0.122
80H12	Mar-93	6.6	7.0	5.9	5.5	0.4	<0.001	<0.001	0.006	0.013	0.030	<0.001	0.025	0.042	0.013	0.129
80H11	Mar-93	7.0	7.5	5.5	5.0	0.5	<0.001	0.005	0.034	0.063	0.147	<0.001	0.018	0.071	0.025	0.362

APPENDIX A (cont.) **GC/MS DATA FOR EGLIN AFB SOIL CORES**

Sample ID	Date	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bot int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80H10	Mar-93	7.5	8.0	5.0	4.5	0.5	0.005	0.030	0.083	0.146	0.328	<0.001	0.043	0.123	0.050	0.808	<10.0
80H9	Mar-93	8.0	8.5	4.5	4.0	0.5	0.012	0.176	0.118	0.195	0.452	0.004	0.049	0.156	0.067	1.230	<10.0
80H8	Mar-93	8.5	9.0	4.0	3.5	0.5	0.027	1.040	0.185	0.257	0.661	0.221	0.074	0.267	0.087	2.819	<10.0
80H7	Mar-93	9.0	9.5	3.5	3.0	0.5	0.049	2.570	0.361	0.478	1.200	0.819	0.142	0.457	0.125	6.201	12.2
80H8	Mar-93	2.5	2.9	8.0	7.6	0.4	0.003	0.018	0.020	0.002	0.049	0.036	<0.001	0.074	0.012	0.214	1050.0
80H7	Mar-93	2.9	3.4	7.6	7.1	0.5	0.003	0.059	0.009	0.027	0.025	0.063	0.048	0.051	0.165	0.448	1000.0
80H6	Mar-93	3.4	3.8	7.1	6.7	0.4	0.024	0.594	0.356	0.180	2.250	4.320	0.000	0.634	0.026	9.384	2760.0
80H5	Mar-93	3.8	4.3	6.7	6.2	0.5	0.056	1.040	0.837	2.540	5.050	8.450	0.000	2.120	0.192	20.285	2610.0
80H4	Mar-93	4.3	4.7	6.2	5.8	0.4	0.085	1.050	1.060	2.590	5.410	6.510	0.494	0.688	0.368	18.225	2010.0
80H3	Mar-93	4.7	5.2	5.8	5.3	0.5	0.008	0.095	0.132	0.275	0.604	0.397	0.022	0.053	0.021	1.607	139.0
80H2	Mar-93	5.2	5.6	5.3	4.9	0.4	0.008	0.003	0.052	0.125	0.271	0.011	0.017	0.038	0.020	0.546	10.4
80H1	Mar-93	5.6	6.0	4.9	4.5	0.4	0.091	0.004	0.051	0.099	0.171	0.012	0.011	0.034	0.014	0.487	<10.0
80H8	Mar-93	2.0	2.5	8.1	7.6	0.5	<0.001	0.005	0.162	0.155	0.058	0.003	0.077	0.568	0.066	1.094	21.4
80H7	Mar-93	2.5	3.0	7.6	7.1	0.5	0.002	0.002	0.114	0.093	0.054	<0.001	0.029	0.365	0.040	0.700	<10.0
80H6	Mar-93	3.0	3.5	7.1	6.6	0.5	0.005	0.003	0.121	0.037	0.053	<0.001	0.054	0.347	0.062	0.682	<10.0
80H5	Mar-93	3.5	4.0	6.6	6.1	0.5	0.004	0.006	0.057	0.008	0.033	<0.001	0.026	0.194	0.027	0.354	<10.0
80H4	Mar-93	4.0	4.5	6.1	5.6	0.5	0.003	<0.001	0.035	0.006	0.043	<0.001	0.014	0.093	0.012	0.207	<10.0
80H3	Mar-93	4.5	5.0	5.6	5.1	0.5	0.004	0.002	0.035	0.005	0.025	<0.001	0.007	0.096	0.018	0.191	<10.0
80H2	Mar-93	5.0	5.5	5.1	4.6	0.5	0.005	0.003	0.028	0.012	0.013	<0.001	0.006	0.084	0.009	0.159	<10.0
80H1	Mar-93	5.5	6.0	4.6	4.1	0.5	0.004	0.002	0.028	0.017	0.005	<0.001	0.008	0.113	0.006	0.214	<10.0
80K5	Mar-93	1.0	1.5	11.5	11.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K4	Mar-93	1.5	2.0	11.0	10.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K3	Mar-93	2.0	2.5	10.5	10.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K2	Mar-93	2.5	3.0	10.0	9.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K1	Mar-93	3.0	3.5	9.5	9.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K11	Mar-93	3.5	3.8	9.0	8.7	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K10	Mar-93	3.8	4.3	8.7	8.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K9	Mar-93	4.3	4.9	8.2	7.6	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K8	Mar-93	4.9	5.4	7.6	7.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K7	Mar-93	5.4	6.0	7.1	6.5	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K15	Mar-93	6.0	6.7	6.5	5.8	0.7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K14	Mar-93	6.7	7.3	5.8	5.2	0.6	<0.001	<0.001	<0.001	0.007	0.011	0.011	<0.001	0.002	<0.001	0.031	<10.0
80K13	Mar-93	7.3	7.9	5.2	4.6	0.6	<0.001	<0.001	0.006	0.048	0.135	0.045	0.015	0.045	0.027	0.321	<10.0
80K12	Mar-93	7.9	8.5	4.6	4.0	0.6	<0.001	<0.001	0.009	0.095	0.265	0.036	0.029	0.063	0.042	0.538	<10.0
80K5	Aug-94	2.2	2.7	10.3	9.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K4	Aug-94	2.7	3.1	9.8	9.4	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K3	Aug-94	3.1	3.6	9.4	8.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K2	Aug-94	3.6	4.0	8.9	8.5	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K1	Aug-94	4.0	4.5	8.5	8.0	0.5	<0.001	0.022	<0.001	<0.001	0.004	<0.001	<0.001	0.003	0.004	0.033	<10.0
80K11	Aug-94	4.5	4.8	8.0	7.7	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K10	Aug-94	4.8	5.2	7.7	7.3	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K9	Aug-94	5.2	5.7	7.3	6.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K8	Aug-94	5.7	6.1	6.8	6.4	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K7	Aug-94	6.1	6.6	6.4	5.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80K6	Aug-94	6.6	7.0	5.9	5.5	0.4	<0.001	<0.001	0.005	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	0.008	<10.0
80K17	Aug-94	7.0	7.5	5.5	5.0	0.5	<0.001	0.007	0.023	0.133	0.323	<0.001	0.015	0.035	0.017	0.552	<10.0

APPENDIX A (cont.) GC/MS DATA FOR EGLIN AFB SOIL CORES

Sample ID	Date	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bot int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80KC16	Aug-94	7.5	7.9	5.0	4.6	0.4	<0.001	0.004	0.013	0.140	0.369	<0.001	0.025	0.054	0.024	0.630	<10.0
80KC15	Aug-94	7.9	8.3	4.6	4.2	0.4	<0.001	<0.001	0.007	0.091	0.277	<0.001	0.025	0.051	0.021	0.472	<10.0
80KC14	Aug-94	8.3	8.7	4.2	3.8	0.4	<0.001	<0.001	0.015	0.034	0.117	<0.001	0.022	0.053	0.016	0.258	<10.0
80KC13	Aug-94	8.7	9.1	3.8	3.4	0.4	<0.001	<0.001	0.007	0.010	0.019	<0.001	0.006	0.016	0.005	0.063	<10.0
80KC12	Aug-94	9.1	9.5	3.4	3.0	0.4	<0.001	<0.001	<0.001	0.006	0.009	<0.001	<0.001	0.009	<0.001	0.025	<10.0
80KD5	May-95	3.0	3.5	9.7	9.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80KD4	May-95	3.5	4.0	9.2	8.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80KD3	May-95	4.0	4.5	8.7	8.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80KD2	May-95	4.5	5.0	8.2	7.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80KD1	May-95	5.0	5.5	7.7	7.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80KD10	May-95	5.5	6.0	7.2	6.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80KD9	May-95	6.0	6.5	6.7	6.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80KD8	May-95	6.5	7.0	6.2	5.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80KD7	May-95	7.0	7.5	5.7	5.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80KD6	May-95	7.5	8.0	5.2	4.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80KD16	May-95	8.0	8.5	4.7	4.2	0.5	<0.001	<0.001	0.014	0.036	0.056	0.010	0.067	0.128	0.028	0.339	<10.0
80KD15	May-95	8.5	8.9	4.2	3.8	0.4	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	0.037	0.047	0.035	0.125	<10.0
80KD14	May-95	8.9	9.3	3.8	3.4	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.021	0.044	0.030	0.096	<10.0
80KD13	May-95	9.3	9.7	3.4	3.0	0.4	<0.001	<0.001	0.005	<0.001	<0.001	<0.001	0.014	0.067	0.035	0.121	<10.0
80KD12	May-95	9.7	10.1	3.0	2.6	0.4	<0.001	<0.001	0.008	<0.001	<0.001	<0.001	0.019	0.064	0.036	0.126	<10.0
80KD11	May-95	10.1	10.5	2.6	2.2	0.4	<0.001	<0.001	0.005	<0.001	<0.001	<0.001	0.013	0.070	0.024	0.112	<10.0
80L8	Mar-93	2.0	2.5	8.6	8.1	0.5	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<10.0
80L7	Mar-93	2.5	3.0	8.1	7.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	<0.001	<0.001	0.005	<10.0
80L6	Mar-93	3.0	3.5	7.6	7.1	0.5	<0.001	0.015	0.010	0.033	0.075	0.092	0.033	0.036	0.018	0.312	13.4
80L5	Mar-93	3.5	4.0	7.1	6.6	0.5	<0.001	0.084	0.054	0.146	0.307	0.323	0.110	0.163	0.070	1.257	17.6
80L4	Mar-93	4.0	4.5	6.6	6.1	0.5	<0.001	0.094	0.064	0.157	0.343	0.315	0.090	0.172	0.071	1.306	13.8
80L3	Mar-93	4.5	5.0	6.1	5.6	0.5	<0.001	0.106	0.097	0.209	0.492	0.415	0.115	0.222	0.085	1.742	18.0
80L2	Mar-93	5.0	5.5	5.6	5.1	0.5	<0.001	0.045	0.066	0.166	0.323	0.258	0.081	0.164	0.070	1.173	<10.0
80L1	Mar-93	5.5	6.0	5.1	4.6	0.5	<0.001	0.011	0.030	0.085	0.179	0.088	0.047	0.101	0.046	0.586	<10.0
80L13	Mar-93	6.0	6.4	4.6	4.2	0.4	<0.001	<0.001	0.005	0.013	0.040	<0.001	0.038	0.108	0.052	0.257	<10.0
80L12	Mar-93	6.4	6.8	4.2	3.8	0.4	<0.001	<0.001	0.004	0.006	0.023	<0.001	0.034	0.099	0.049	0.216	<10.0
80L11	Mar-93	6.8	7.2	3.8	3.4	0.4	<0.001	<0.001	0.005	0.004	0.015	<0.001	0.028	0.093	0.043	0.187	<10.0
80L10	Mar-93	7.2	7.6	3.4	3.0	0.4	<0.001	<0.001	0.011	0.002	0.017	<0.001	0.034	0.112	0.041	0.216	<10.0
80L9	Mar-93	7.6	8.0	3.0	2.6	0.4	<0.001	<0.001	0.009	<0.001	0.007	<0.001	0.003	0.068	0.025	0.113	<10.0
80M8	Mar-93	3.0	3.5	8.5	8.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80M7	Mar-93	3.5	4.0	8.0	7.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80M6	Mar-93	4.0	4.5	7.5	7.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80M5	Mar-93	4.5	5.0	7.0	6.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80M4	Mar-93	5.0	5.5	6.5	6.0	0.5	<0.001	<0.001	<0.001	0.002	0.005	<0.001	0.008	0.016	0.009	0.039	<10.0
80M3	Mar-93	5.5	6.0	6.0	5.5	0.5	<0.001	<0.001	0.009	0.019	0.045	<0.001	0.037	0.079	0.038	0.227	<10.0
80M2	Mar-93	6.0	6.5	5.5	5.0	0.5	<0.001	0.018	0.040	0.075	0.178	<0.001	0.044	0.118	0.052	0.526	<10.0
80M1	Mar-93	6.5	7.0	5.0	4.5	0.5	<0.001	<0.001	0.044	0.084	0.196	<0.001	0.032	0.102	0.053	0.511	<10.0
80N7	Mar-93	2.0	2.5	11.2	10.7	0.5	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.002	<0.001	0.015	0.020	96.8
80N6	Mar-93	2.5	3.0	10.7	10.2	0.5	<0.001	0.012	<0.001	<0.001	0.016	0.034	<0.001	0.003	0.003	0.073	1180.0
80N5	Mar-93	3.0	3.5	10.2	9.7	0.5	<0.001	0.009	0.005	0.029	0.039	<0.001	<0.001	0.055	0.015	0.151	684.0
80N4	Mar-93	3.5	4.0	9.7	9.2	0.5	<0.001	0.013	<0.001	0.033	0.003	<0.001	0.109	<0.001	0.029	0.186	693.0

APPENDIX A (cont.) **GC/MS DATA FOR EGLIN AFB SOIL CORES**

Sample ID	Date	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bot int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80N3	Mar-93	4.0	4.5	9.2	8.7	0.5	<0.001	0.009	0.003	0.016	0.016	0.050	1.370	0.109	0.134	1.707	807.0
80N2	Mar-93	4.5	5.0	8.7	8.2	0.5	<0.001	0.054	1.800	3.580	8.890	4.600	11.200	29.000	7.170	66.294	3370.0
80N1	Mar-93	5.0	5.5	8.2	7.7	0.5	<0.001	1.590	13.200	22.600	58.100	32.500	24.400	72.700	23.200	248.290	7850.0
80N14	Mar-93	5.5	5.7	7.7	7.5	0.2	0.006	16.800	57.900	81.100	209.000	129.000	40.700	138.000	41.900	714.406	14700.0
80N13	Mar-93	5.7	6.1	7.5	7.1	0.4	0.057	40.700	65.700	82.500	208.000	131.000	34.000	117.000	35.800	714.757	14800.0
80N12	Mar-93	6.1	6.6	7.1	6.6	0.5	0.017	0.737	0.309	0.387	0.955	0.649	0.109	0.401	0.128	3.692	32.5
80N10	Mar-93	6.6	7.5	6.6	5.7	0.9	0.024	0.030	0.221	0.265	0.656	0.067	0.040	0.154	0.060	1.517	<10.0
80N9	Mar-93	7.5	8.0	5.7	5.2	0.5	0.003	<0.001	0.053	0.063	0.159	0.002	0.008	0.032	<0.001	0.320	<10.0
80N8	Mar-93	8.0	8.5	5.2	4.7	0.5	0.003	0.007	0.073	0.090	0.227	0.024	0.017	0.062	0.022	0.527	<10.0
80O4	Jul-93	<0.001	0.3	11.8	11.5	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	21.2
80O3	Jul-93	0.3	0.9	11.5	10.9	0.6	<0.001	0.004	<0.001	<0.001	0.004	0.005	<0.001	<0.001	<0.001	0.013	<10.0
80O2	Jul-93	0.9	1.4	10.9	10.4	0.5	<0.001	0.007	<0.001	0.003	0.007	0.006	<0.001	<0.001	<0.001	0.023	<10.0
80O1	Jul-93	1.4	2.0	10.4	9.8	0.6	0.009	0.164	0.144	0.189	0.546	0.458	0.089	0.265	0.096	1.961	14.3
80O8	Jul-93	2.0	2.3	9.8	9.5	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	22.0
80O7	Jul-93	2.3	2.9	9.5	8.9	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	14.5
80O6	Jul-93	2.9	3.4	8.9	8.4	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80O5	Jul-93	3.4	4.0	8.4	7.8	0.6	<0.001	0.278	0.022	0.043	0.063	<0.001	0.237	0.238	0.040	0.921	232.0
80O13	Jul-93	4.0	4.4	7.8	7.4	0.4	<0.001	0.816	4.730	7.040	13.000	0.071	21.100	45.900	13.300	105.957	10700.0
80O12	Jul-93	4.4	4.9	7.4	6.9	0.5	<0.001	0.096	1.750	3.100	5.410	0.152	7.440	14.200	4.620	36.758	2510.0
80O11	Jul-93	4.9	5.4	6.9	6.4	0.5	<0.001	0.047	0.011	0.018	0.022	<0.001	0.022	0.046	0.022	0.160	<10.0
80O10	Jul-93	5.4	6.0	6.4	5.8	0.6	<0.001	0.042	0.005	0.012	0.017	<0.001	0.017	0.087	0.039	0.240	<10.0
80O9	Jul-93	6.0	6.5	5.8	5.3	0.5	<0.001	0.041	0.006	0.015	0.020	<0.001	0.031	0.067	0.023	0.208	<10.0
80O17	Jul-93	6.5	7.2	5.3	4.6	0.7	<0.001	0.054	0.005	0.012	0.017	<0.001	0.015	0.037	0.013	0.156	<10.0
80O16	Jul-93	7.2	7.8	4.6	4.0	0.6	<0.001	0.045	0.008	0.015	0.023	<0.001	0.017	0.041	0.010	0.206	<10.0
80O15	Jul-93	7.8	8.4	4.0	3.4	0.6	0.008	0.041	0.017	0.026	0.048	<0.001	0.034	0.072	<0.001	0.547	<10.0
80O14	Jul-93	8.4	9.0	3.4	2.8	0.6	0.025	0.047	0.079	0.085	0.204	<0.001	0.048	0.124	0.027	0.700	<10.0
80O20	Jul-93	9.0	9.3	2.8	2.5	0.3	0.028	0.057	0.097	0.141	0.178	<0.001	0.045	0.129	0.029	0.754	<10.0
80O19	Jul-93	9.3	9.8	2.5	2.0	0.5	0.033	0.044	0.113	0.163	0.197	<0.001	0.030	0.102	0.022	0.569	<10.0
80O18	Jul-93	9.8	10.3	2.0	1.5	0.5	0.022	<0.001	0.114	0.167	0.112	<0.001	0.029	0.084	0.018	0.431	<10.0
-	Jul-93	10.3	11.5	1.5	0.3	1.2	0.013	<0.001	0.066	0.112	0.108	<0.001	0.027	0.065	0.015	0.293	<10.0
80O24	Jul-93	11.5	11.9	0.3	-0.1	0.4	0.005	<0.001	0.018	0.058	0.104	<0.001	0.049	0.109	0.025	0.515	11.5
80O23	Jul-93	11.9	12.4	-0.1	-0.6	0.6	0.009	<0.001	0.036	0.112	0.175	<0.001	0.038	0.105	0.021	0.741	<10.0
80O22	Jul-93	12.4	13.0	-0.6	-1.2	0.6	0.023	0.039	0.073	0.150	0.293	<0.001	0.030	0.090	0.021	0.593	<10.0
80O21	Jul-93	13.0	13.5	-1.2	-1.7	0.5	0.020	<0.001	0.055	0.132	0.245	<0.001	0.018	0.047	0.013	0.216	<10.0
80O27	Jul-93	13.5	13.8	-1.7	-2.0	0.3	0.005	<0.001	0.017	0.032	0.085	<0.001	0.025	0.065	0.019	0.283	<10.0
80O26	Jul-93	14.3	14.3	-2.0	-2.5	0.5	0.005	<0.001	0.022	0.042	0.105	<0.001	0.046	0.107	0.034	0.387	11.1
80O25	Jul-93	14.3	14.8	-2.5	-3.0	0.5	0.006	<0.001	0.028	0.052	0.115	<0.001	0.023	0.054	0.017	0.194	<10.0
-	Jul-93	14.8	16.0	-3.0	-4.2	1.2	0.003	<0.001	0.014	0.026	0.058	<0.001	0.023	<0.001	<0.001	0.194	<10.0
80O33	Jul-93	16.0	16.4	-4.2	-4.6	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80O32	Jul-93	16.4	16.8	-4.6	-5.0	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<10.0
80O31	Jul-93	16.8	17.2	-5.0	-5.4	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	0.003	<10.0
80O30	Jul-93	17.2	17.6	-5.4	-5.8	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80O29	Jul-93	17.6	18.0	-5.8	-6.2	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80O28	Jul-93	18.0	18.4	-6.2	-6.6	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80P5	Jul-93	<0.001	0.5	12.6	12.1	0.5	<0.001	0.163	<0.001	<0.001	0.011	0.009	<0.001	<0.001	<0.001	0.183	12.9
80P4	Jul-93	0.5	1.0	12.1	11.6	0.5	<0.001	0.019	0.006	0.008	0.013	0.011	<0.001	<0.001	<0.001	0.057	15.2
80P3	Jul-93	1.0	1.5	11.6	11.1	0.5	<0.001	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	<10.0
80P2	Jul-93	1.5	2.0	11.1	10.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0

APPENDIX A (cont.) GC/MS DATA FOR EGLIN AFB SOIL CORES

Sample ID	Date	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bot int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80P1	Jul-93	2.0	2.5	10.6	10.1	0.5	<0.001	0.006	<0.001	<0.001	0.006	<0.001	<0.001	<0.001	<0.001	0.012	<10.0
80P10	Jul-93	2.5	3.0	10.1	9.6	0.5	<0.001	0.006	<0.001	<0.001	0.005	<0.001	<0.001	<0.001	<0.001	0.011	18.5
80P9	Jul-93	3.0	3.5	9.6	9.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	11.2
80P8	Jul-93	3.5	4.0	9.1	8.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	10.6
80P7	Jul-93	4.0	4.5	8.6	8.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	116.0
80P6	Jul-93	4.5	5.0	8.1	7.6	0.5	<0.001	0.003	0.007	0.009	<0.001	0.032	0.976	1.370	0.920	8.232	2350.0
80P15	Jul-93	5.0	5.3	7.6	7.3	0.3	<0.001	0.063	0.073	0.159	0.336	0.186	5.070	0.512	0.223	1.995	51.8
80P14	Jul-93	5.3	5.9	7.3	6.7	0.6	<0.001	0.059	0.091	0.159	0.336	0.267	0.348	0.655	0.275	3.206	40.7
80P13	Jul-93	5.9	6.4	6.7	6.2	0.5	<0.001	0.096	0.198	0.362	0.825	0.510	0.285	0.637	0.284	2.789	23.9
80P12	Jul-93	6.4	7.0	6.2	5.6	0.6	<0.001	0.106	0.118	0.362	0.678	0.050	0.235	0.587	0.281	2.448	16.5
80P11	Jul-93	7.0	7.5	5.6	5.1	0.5	0.003	0.134	0.118	0.362	0.678	0.050	0.235	0.587	0.281	2.448	16.5
80P20	Jul-93	7.5	7.7	5.1	4.9	0.2	0.020	0.133	0.101	0.235	0.509	0.003	0.127	0.266	0.111	1.504	12.3
80P19	Jul-93	7.7	8.3	4.9	4.3	0.6	0.036	0.695	0.184	0.400	0.938	0.041	0.192	0.421	0.163	3.069	14.0
80P18	Jul-93	8.3	8.9	4.3	3.7	0.6	0.048	2.180	0.336	0.727	1.630	0.489	0.216	0.554	0.229	6.409	12.6
80P17	Jul-93	8.9	9.5	3.7	3.1	0.6	0.047	1.970	0.372	0.803	1.800	0.725	0.234	0.615	0.244	6.810	11.1
80P16	Jul-93	9.5	10.0	3.1	2.6	0.5	0.043	1.980	0.388	0.808	1.820	0.929	0.256	0.715	0.270	7.209	10.7
80P23	Jul-93	10.0	10.5	2.6	2.1	0.5	0.003	0.044	0.017	0.045	0.111	0.023	0.026	0.067	0.025	0.359	<10.0
80P22	Jul-93	10.5	11.0	2.1	1.6	0.5	0.003	0.049	0.018	0.051	0.124	0.024	0.029	0.075	0.027	0.399	<10.0
80P21	Jul-93	11.0	11.5	1.6	1.1	0.5	0.006	0.133	0.053	0.125	0.265	0.075	0.062	0.155	0.058	0.932	<10.0
80P27	Jul-93	13.0	13.5	-0.4	-0.9	0.5	<0.001	0.083	0.031	0.090	0.245	0.042	0.042	0.108	0.042	0.686	<10.0
80P26	Jul-93	13.5	14.0	-0.9	-1.4	0.5	0.004	0.086	0.021	0.078	0.266	0.027	0.037	0.100	0.038	0.657	<10.0
80P25	Jul-93	14.0	14.5	-1.4	-1.9	0.5	0.003	0.076	0.019	0.071	0.244	0.024	0.033	0.082	0.033	0.585	<10.0
80P24	Jul-93	14.5	15.0	-1.9	-2.4	0.5	0.002	0.051	0.013	0.042	0.151	0.017	0.024	0.059	0.024	0.384	<10.0
80P29	Jul-93	15.0	18.0	-2.4	-5.4	3.0	0.004	0.135	0.027	0.067	0.187	0.045	0.066	0.093	0.039	0.641	<10.0
80P28	Jul-93	18.0	18.5	-5.4	-5.9	0.5	0.006	0.219	0.041	0.091	0.222	0.072	0.066	0.127	0.054	0.898	11.8
80Q1	Jul-93	2.0	2.5	11.2	10.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Q7	Jul-93	2.5	2.7	10.7	10.5	0.2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Q6	Jul-93	2.7	3.2	10.5	10.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Q5	Jul-93	3.2	3.6	10.0	9.6	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Q4	Jul-93	3.6	4.1	9.6	9.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Q3	Jul-93	4.1	4.5	9.1	8.7	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Q2	Jul-93	4.5	5.0	8.7	8.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	18.0
80Q12	Jul-93	5.0	5.4	8.2	7.8	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Q11	Jul-93	5.4	6.0	7.8	7.2	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Q10	Jul-93	6.0	6.5	7.2	6.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Q9	Jul-93	6.5	7.0	6.7	6.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Q8	Jul-93	7.0	7.5	6.2	5.7	0.5	<0.001	<0.001	0.013	0.086	0.240	0.027	0.004	0.024	<0.001	0.365	<10.0
80Q19	Jul-93	7.5	7.9	5.3	5.3	0.4	<0.001	<0.001	0.023	0.121	0.323	0.024	0.004	0.024	0.034	0.539	<10.0
80Q18	Jul-93	7.9	8.2	5.3	5.0	0.3	<0.001	<0.001	0.034	0.147	0.410	0.031	0.011	0.047	0.034	0.714	<10.0
80Q17	Jul-93	8.2	8.6	5.0	4.6	0.4	<0.001	<0.001	0.035	0.111	0.266	0.021	0.020	0.059	0.033	0.543	<10.0
80Q16	Jul-93	8.6	8.9	4.6	4.3	0.3	<0.001	<0.001	0.027	0.078	0.185	0.005	0.032	0.064	0.030	0.380	<10.0
80Q15	Jul-93	8.9	9.3	4.3	3.9	0.4	<0.001	<0.001	0.018	0.068	0.169	<0.001	0.016	0.030	0.015	0.147	<10.0
80Q14	Jul-93	9.3	9.6	3.9	3.6	0.3	<0.001	<0.001	<0.001	0.018	0.066	<0.001	0.015	0.030	0.013	0.117	<10.0
80Q13	Jul-93	9.6	10.0	3.6	3.2	0.4	<0.001	<0.001	<0.001	0.007	0.052	<0.001	0.015	0.006	0.003	0.033	<10.0
80Q23	Jul-93	10.0	10.5	3.2	2.7	0.5	<0.001	<0.001	<0.001	0.003	0.018	<0.001	0.002	0.002	<0.001	0.003	<10.0
80Q22	Jul-93	10.5	11.0	2.7	2.2	0.5	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Q21	Jul-93	11.0	11.5	2.2	1.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0

APPENDIX A (cont.) GC/MS DATA FOR EGLIN AFB SOIL CORES

Sample ID	Date	Lo Int (ft)	Hi Int (ft)	Top Int (ft MSL)	Bot Int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80Q20	Jul-93	11.5	12.0	1.7	1.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80R1	Jul-93	2.0	2.5	11.7	11.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	13.2
80R6	Jul-93	2.5	3.0	11.2	10.7	0.5	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	0.004	<10.0
80R5	Jul-93	3.0	3.5	10.7	10.2	0.5	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	<0.001	0.006	<0.001	0.004	<10.0
80R4	Jul-93	3.5	4.0	10.2	9.7	0.5	<0.001	0.005	0.004	0.007	0.013	0.008	<0.001	<0.001	<0.001	0.042	<10.0
80R3	Jul-93	4.0	4.5	9.7	9.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80R2	Jul-93	4.5	5.0	9.2	8.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80R10	Jul-93	5.0	5.6	8.7	8.1	0.6	0.012	0.068	<0.001	0.233	0.336	1.960	8.580	0.211	7.350	18.750	3910.0
80R9	Jul-93	5.6	6.2	8.1	7.5	0.6	<0.001	0.029	0.590	5.600	7.620	12.900	25.300	29.300	25.100	106.440	7720.0
80R8	Jul-93	6.2	6.8	7.5	6.9	0.6	<0.001	0.009	0.060	0.170	0.378	0.394	0.219	0.513	0.250	1.993	39.6
80R7	Jul-93	6.8	7.5	6.9	6.2	0.7	<0.001	0.005	0.068	0.123	0.289	0.234	0.057	0.117	0.064	0.957	13.3
80R15	Jul-93	7.5	7.9	6.2	5.8	0.4	<0.001	<0.001	0.006	0.033	0.033	0.033	0.033	0.037	0.037	0.212	18.6
80R14	Jul-93	7.9	8.3	5.8	5.4	0.4	<0.001	<0.001	<0.001	<0.001	0.003	0.003	0.002	0.005	0.003	0.016	<10.0
80R13	Jul-93	8.3	8.7	5.4	5.0	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80R12	Jul-93	8.7	9.1	5.0	4.6	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80R11	Jul-93	9.1	9.5	4.6	4.2	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80S1	Jul-93	2.0	2.5	11.1	10.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80S5	Jul-93	2.5	3.1	10.6	10.0	0.6	<0.001	<0.001	<0.001	0.013	0.005	<0.001	0.004	0.006	<0.001	0.027	278.0
80S4	Jul-93	3.1	3.7	10.0	9.4	0.6	<0.001	0.061	0.008	0.026	0.042	0.099	0.123	0.014	0.083	0.457	1830.0
80S3	Jul-93	3.7	4.3	9.4	8.8	0.6	<0.001	0.019	0.067	0.252	0.439	0.448	1.390	0.213	1.210	4.038	1910.0
80S2	Jul-93	4.3	5.0	8.8	8.1	0.7	<0.001	0.043	0.761	2.060	4.070	1.940	5.650	3.170	6.250	23.944	2040.0
80S9	Jul-93	5.0	5.3	8.1	7.8	0.3	0.009	1.410	29.200	52.900	118.000	62.300	50.000	128.000	58.200	499.919	11700.0
80S8	Jul-93	5.3	5.9	7.8	7.2	0.6	0.047	6.470	80.300	107.000	215.000	117.000	49.400	122.000	51.400	748.617	16300.0
80S7	Jul-93	5.9	6.5	7.2	6.6	0.6	0.005	0.043	0.397	0.573	1.330	0.290	0.209	0.596	0.293	3.736	4720.0
80S6	Jul-93	6.5	7.0	6.6	6.1	0.5	<0.001	<0.001	0.012	0.021	0.046	0.033	0.008	0.019	0.013	0.153	<10.0
80S13	Jul-93	7.0	7.5	6.1	5.6	0.5	<0.001	<0.001	0.010	0.016	0.035	0.021	0.008	0.017	0.010	0.117	<10.0
80S12	Jul-93	7.5	8.1	5.6	5.0	0.6	<0.001	<0.001	0.007	0.010	0.024	0.010	0.007	0.016	0.007	0.081	<10.0
80S11	Jul-93	8.1	8.7	5.0	4.4	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80S10	Jul-93	8.7	9.3	4.4	3.8	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80S10	Jul-93	9.3	10.0	3.8	3.1	0.7	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.002	<0.001	0.004	<10.0
80T4	Jul-93	3.0	3.5	9.5	9.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80T3	Jul-93	3.5	4.0	9.0	8.5	0.5	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	0.003	<0.001	0.006	<10.0
80T2	Jul-93	4.0	4.5	8.5	8.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80T1	Jul-93	4.5	5.0	8.0	7.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80T8	Jul-93	5.0	5.6	7.5	6.9	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80T7	Jul-93	5.6	6.2	6.9	6.3	0.6	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80T6	Jul-93	6.2	6.8	6.3	5.7	0.6	<0.001	<0.001	<0.001	0.013	<0.001	0.007	<0.001	0.023	0.008	0.051	<10.0
80T5	Jul-93	6.8	7.5	5.7	5.0	0.7	<0.001	0.002	0.008	0.092	0.170	0.076	0.013	0.042	0.026	0.428	<10.0
80T12	Jul-93	7.5	8.1	5.0	4.4	0.6	<0.001	<0.001	<0.001	0.077	0.220	0.012	0.023	0.050	0.028	0.411	<10.0
80T11	Jul-93	8.1	8.7	4.4	3.8	0.6	<0.001	<0.001	0.003	0.133	0.373	0.003	0.040	0.086	0.043	0.680	<10.0
80T10	Jul-93	8.9	9.3	3.6	3.2	0.6	0.004	<0.001	0.006	0.152	0.417	0.004	0.040	0.082	0.045	0.749	<10.0
80T9	Jul-93	9.3	10.0	3.2	2.5	0.7	0.011	<0.001	0.005	0.171	0.454	<0.001	0.038	0.085	0.044	0.808	<10.0
80U13	Mar-94	1.2	1.7	11.7	11.2	0.5	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	<0.001	0.009	0.006	0.021	<10.0
80U12	Mar-94	1.7	2.2	11.2	10.7	0.5	<0.001	0.009	<0.001	<0.001	0.007	<0.001	<0.001	0.010	<0.001	0.026	<10.0
80U11	Mar-94	2.2	2.7	10.7	10.2	0.5	<0.001	0.017	0.010	<0.001	0.010	0.014	0.584	0.020	0.287	0.941	1000.0
80U10	Mar-94	2.7	3.2	10.2	9.7	0.5	<0.001	0.014	<0.001	<0.001	0.014	0.065	1.610	0.113	0.784	2.600	837.0

APPENDIX A (cont.) **GC/MS DATA FOR EGLIN AFB SOIL CORES**

Sample ID	Date	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bol int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB: TPH (as JP-4) (mg/kg)
80U5	Mar-94	3.2	3.5	9.7	9.4	0.3	<0.001	0.007	<0.001	0.007	0.011	0.038	0.919	0.068	0.402	1.452
80U5	Mar-94	3.5	3.7	9.4	9.2	0.2	<0.001	<0.001	<0.001	0.015	0.008	0.011	0.228	0.023	0.020	0.304
80U4	Mar-94	3.7	4.2	9.2	8.7	0.5	<0.001	0.007	0.068	0.183	0.287	0.329	3.750	0.952	1.060	959.0
80U3	Mar-94	4.2	4.7	8.7	8.2	0.5	0.021	8.390	21.100	32.000	72.200	49.700	43.600	90.500	39.200	6.636
80U2	Mar-94	4.7	5.2	8.2	7.7	0.5	0.151	39.800	60.000	80.000	184.000	120.000	57.700	153.000	60.200	356.711
80U1	Mar-94	5.2	5.7	7.7	7.2	0.5	0.237	57.500	51.400	59.700	138.000	84.200	26.700	76.000	30.300	12000.0
80U9	Mar-94	5.7	6.0	7.2	6.9	0.3	0.123	30.825	27.195	31.545	73.045	44.645	14.195	40.155	16.035	755.651
80U8	Mar-94	6.4	6.8	6.5	6.1	0.4	<0.001	1.260	0.590	0.833	8.090	5.090	1.690	4.310	1.770	10300.0
80U7	Mar-94	6.8	7.2	6.1	5.7	0.4	0.005	1.060	0.683	0.838	1.960	1.000	0.406	0.897	0.247	682.0
80U6	Mar-94	7.2	7.6	5.7	5.3	0.4	<0.001	0.405	0.441	0.569	1.330	0.312	0.255	0.641	0.241	6.352
80U18	Mar-94	7.6	7.9	5.3	5.0	0.3	<0.001	0.240	0.364	0.468	1.080	0.185	0.224	0.662	0.248	4.194
80U17	Mar-94	7.9	8.4	5.0	4.5	0.5	0.006	0.406	0.740	1.040	2.300	0.254	0.449	1.230	0.398	3.471
80U16	Mar-94	8.4	8.9	4.5	4.0	0.5	<0.001	0.054	0.372	0.503	1.200	0.028	0.272	0.572	0.195	6.823
80U15	Mar-94	8.9	9.4	4.0	3.5	0.5	0.006	0.023	0.297	0.649	1.350	0.024	0.366	1.100	0.216	44.7
80U14	Mar-94	9.4	9.9	3.5	3.0	0.5	0.004	0.012	0.220	0.419	0.698	0.014	0.252	0.955	0.121	7.180
80U22	Mar-94	10.6	11.1	2.3	1.8	0.5	<0.001	0.065	0.098	0.185	0.261	0.078	0.159	0.693	0.095	4.194
80U21	Mar-94	11.1	11.6	1.8	1.3	0.5	<0.001	0.026	0.047	0.097	0.079	0.040	0.044	0.430	0.068	1.973
80U20	Mar-94	11.6	12.1	1.3	0.8	0.5	0.006	0.015	0.031	0.110	0.053	0.016	0.009	0.268	0.079	1.251
80U19	Mar-94	12.1	12.6	0.8	0.3	0.5	0.005	0.024	0.040	0.139	0.067	0.021	0.014	0.293	0.115	0.647
80V4	Mar-94	3.6	4.1	10.2	9.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.656
80V3	Mar-94	4.1	4.6	9.7	9.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80V2	Mar-94	4.6	5.1	9.2	8.7	0.5	<0.001	0.767	0.299	2.970	4.860	7.960	13.500	4.680	10.700	53.4
80V1	Mar-94	5.1	5.6	8.7	8.2	0.5	<0.001	8.990	7.170	18.100	36.700	28.200	19.600	33.200	17.300	45.736
80V10	Mar-94	5.6	6.5	8.2	7.3	0.9	<0.001	4.867	3.794	9.340	19.020	14.615	9.975	17.088	8.815	169.260
80V9	Mar-94	6.5	6.8	7.3	7.0	0.3	<0.001	0.744	0.418	0.580	1.340	1.030	0.350	0.975	0.329	87.513
80V8	Mar-94	6.8	7.2	7.0	6.6	0.4	<0.001	1.960	0.857	1.140	2.400	1.660	0.487	1.510	0.454	5.766
80V7	Mar-94	7.2	7.6	6.6	6.2	0.4	<0.001	1.480	0.731	1.040	2.400	1.660	0.510	1.510	0.454	10.949
80V6	Mar-94	7.6	8.0	6.2	5.8	0.4	<0.001	0.034	0.030	0.095	0.245	0.053	0.094	0.249	0.059	9.785
80V5	Mar-94	8.0	8.4	5.8	5.4	0.4	<0.001	0.007	<0.001	0.098	0.027	0.006	0.018	0.226	0.012	0.858
80V18	Mar-94	8.4	8.8	5.4	5.0	0.4	<0.001	0.094	0.051	0.170	0.331	0.281	0.255	0.431	0.226	0.131
80V17	Mar-94	8.8	9.5	5.0	4.3	0.7	<0.001	0.078	0.035	0.105	0.207	0.177	0.156	0.279	0.137	1.839
80V16	Mar-94	9.5	9.7	4.3	4.1	0.2	<0.001	0.061	0.019	0.041	0.083	0.072	0.058	0.126	0.048	1.174
80V15	Mar-94	9.7	10.0	4.1	3.8	0.3	<0.001	0.013	<0.001	0.007	0.021	0.012	0.014	0.043	0.007	0.508
80V14	Mar-94	10.3	10.6	3.8	3.5	0.3	<0.001	0.007	<0.001	<0.001	0.020	<0.001	0.013	0.050	<0.001	0.116
80V13	Mar-94	10.3	10.6	3.5	3.2	0.3	<0.001	0.004	<0.001	<0.001	0.017	<0.001	0.012	0.034	<0.001	0.090
80V12	Mar-94	10.6	10.9	3.2	2.9	0.3	<0.001	<0.001	<0.001	0.025	0.026	<0.001	0.011	0.034	<0.001	0.067
80V11	Mar-94	10.9	11.3	2.9	2.5	0.4	<0.001	<0.001	<0.001	0.016	0.016	<0.001	0.006	0.027	<0.001	0.097
80W6	Aug-94	11.3	11.6	2.5	2.2	0.3	<0.001	0.005	<0.001	<0.001	0.009	<0.001	<0.001	0.029	<0.001	0.043
80W5	Aug-94	11.6	12.0	2.2	1.8	0.4	<0.001	0.124	0.036	0.066	0.155	0.115	0.040	0.117	0.033	0.687
80W4	Aug-94	1.0	1.2	11.0	10.8	0.2	<0.001	0.007	<0.001	0.006	0.010	0.008	0.006	0.006	<0.001	0.042
80W3	Aug-94	1.2	1.7	10.8	10.3	0.5	<0.001	0.007	<0.001	0.008	0.012	0.013	0.008	0.008	0.006	0.062
80W2	Aug-94	1.7	2.1	10.3	9.9	0.4	<0.001	<0.001	<0.001	0.005	0.008	0.009	0.006	0.007	0.005	0.041
80W1	Aug-94	2.1	2.6	9.9	9.4	0.5	<0.001	<0.001	<0.001	0.005	0.009	0.010	0.006	0.007	0.005	0.040
80W13	Aug-94	2.6	3.0	9.4	9.0	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.004	0.004	<0.001	0.012
80W12	Aug-94	3.0	3.5	9.0	8.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.012
80W11	Aug-94	3.5	3.6	8.5	8.4	0.1	<0.001	0.009	<0.001	0.013	0.010	<0.001	0.012	0.015	0.010	0.069
80W10	Aug-94	3.6	3.6	8.5	8.4	0.1	<0.001	0.009	<0.001	0.013	0.010	<0.001	0.012	0.015	0.010	0.069

APPENDIX A (cont.) GC/MS DATA FOR EGLIN AFB SOIL CORES

Sample ID	Date	Lo.int (ft)	Hi.int (ft)	Top.int (ft MSL)	Bot.int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80W12	Aug-94	3.6	4.0	8.4	8.0	0.4	<0.001	<0.001	0.019	0.272	0.288	0.421	11.400	9.130	10.100	31.624	4800.0
80W11	Aug-94	4.0	4.4	8.0	7.6	0.4	<0.001	0.013	0.038	0.346	0.288	0.572	8.520	8.310	26.668	26.668	3340.0
80W10	Aug-94	4.4	4.8	7.6	7.2	0.4	<0.001	0.007	0.008	0.067	0.054	0.077	2.020	3.260	2.470	7.962	904.0
80W9	Aug-94	4.8	5.2	7.2	6.8	0.4	<0.001	0.037	0.078	0.746	0.686	1.040	14.500	25.400	16.100	58.587	6260.0
80W8	Aug-94	5.2	5.6	6.8	6.4	0.4	<0.001	<0.001	0.007	0.047	0.043	0.070	0.716	1.290	0.830	3.003	295.0
80W7	Aug-94	5.6	6.0	6.4	6.0	0.4	<0.001	<0.001	<0.001	0.008	0.008	0.009	0.153	0.386	0.256	0.820	53.8
80W19	Aug-94	6.0	6.5	6.0	5.5	0.5	<0.001	0.005	<0.001	<0.001	<0.001	<0.001	0.007	0.035	0.017	0.065	<10.0
80W18	Aug-94	6.5	6.9	5.5	5.1	0.4	<0.001	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	0.004	<10.0
80W17	Aug-94	6.9	7.3	5.1	4.7	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80W16	Aug-94	7.3	7.7	4.7	4.3	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.005	<0.001	0.008	<10.0
80W15	Aug-94	7.7	8.1	4.3	3.9	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.016	0.025	0.018	0.059	<10.0
80W14	Aug-94	8.1	8.5	3.9	3.5	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80X6	Aug-94	2.0	2.3	10.5	10.2	0.3	0.025	0.108	2.250	4.420	9.210	0.252	7.810	11.800	7.300	43.175	2280.0
80X5	Aug-94	2.3	2.7	10.2	9.8	0.4	0.049	0.204	4.660	8.860	17.800	0.506	15.300	24.400	13.700	85.479	5570.0
80X4	Aug-94	2.7	3.2	9.8	9.3	0.5	0.028	0.107	2.700	5.800	10.100	0.359	11.000	20.000	10.300	60.394	3780.0
80X3	Aug-94	3.2	3.6	9.3	8.9	0.4	0.016	0.039	0.635	2.330	2.540	0.142	5.240	12.700	6.990	30.632	2770.0
80X2	Aug-94	3.6	4.1	8.9	8.4	0.5	0.009	0.016	0.054	0.500	0.223	0.047	0.840	6.070	2.840	10.602	1600.0
80X1	Aug-94	4.1	4.5	8.4	8.0	0.4	0.007	0.016	0.062	0.355	0.209	0.019	1.320	8.410	3.770	14.168	1770.0
80X12	Aug-94	4.5	5.0	8.0	7.5	0.5	0.027	0.132	115.000	129.000	363.000	0.011	81.300	215.000	74.500	978.020	25300.0
80X11	Aug-94	5.0	5.4	7.5	7.1	0.4	0.277	0.143	133.000	146.000	356.000	0.071	869.000	216.000	80.300	1800.741	25700.0
80X10	Aug-94	5.4	5.8	7.1	6.7	0.4	0.130	0.052	37.600	39.100	70.700	0.068	23.000	56.800	21.700	249.150	7290.0
80X9	Aug-94	5.8	6.2	6.7	6.3	0.4	0.028	0.010	3.290	3.700	8.940	0.004	2.290	6.040	2.180	26.483	524.0
80X8	Aug-94	6.2	6.6	6.3	5.9	0.4	0.260	0.259	0.580	0.595	0.892	0.187	0.275	0.449	0.255	3.752	10.2
80X7	Aug-94	6.6	7.0	5.9	5.5	0.4	0.020	0.014	0.341	0.374	0.742	0.027	0.076	0.261	0.097	1.952	<10.0
80X18	Aug-94	7.0	7.3	5.5	5.2	0.3	<0.001	0.020	0.265	0.337	0.740	0.257	0.176	0.448	0.204	2.449	45.3
80X17	Aug-94	7.3	7.7	5.2	4.8	0.4	<0.001	0.014	0.222	0.255	0.609	0.265	0.064	0.209	0.080	1.717	<10.0
80X16	Aug-94	7.7	8.2	4.8	4.3	0.5	<0.001	0.006	0.246	0.273	0.659	0.033	0.069	0.224	0.074	1.584	<10.0
80X15	Aug-94	8.2	8.6	4.3	3.9	0.4	<0.001	0.017	0.273	0.324	0.715	0.254	0.073	0.229	0.084	1.969	<10.0
80X14	Aug-94	8.6	9.1	3.9	3.4	0.5	0.009	0.014	0.307	0.344	0.667	0.160	0.074	0.246	0.093	1.913	10.2
80X13	Aug-94	9.1	9.5	3.4	3.0	0.4	0.014	0.004	0.302	0.333	0.245	0.008	0.062	0.281	0.078	1.327	12.0
80Y6	Aug-94	2.0	2.4	10.2	9.8	0.4	<0.001	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	<10.0
80Y5	Aug-94	2.4	2.8	9.8	9.4	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Y4	Aug-94	2.8	3.2	9.4	9.0	0.4	<0.001	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<10.0
80Y3	Aug-94	3.2	3.6	9.0	8.6	0.4	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	30.5
80Y2	Aug-94	3.6	4.0	8.6	8.2	0.4	<0.001	<0.001	<0.001	0.010	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	186.0
80Y1	Aug-94	4.0	4.5	8.2	7.7	0.5	<0.001	0.030	0.016	0.047	0.060	0.101	0.109	0.899	0.187	1.449	5350.0
80Y13	Aug-94	4.5	4.6	7.7	7.6	0.1	<0.001	<0.001	0.499	1.270	2.380	1.110	3.700	8.680	3.150	20.789	1080.0
80Y12	Aug-94	4.6	5.0	7.6	7.2	0.4	<0.001	0.007	0.511	1.180	2.550	1.140	2.180	5.700	2.110	15.378	564.0
80Y11	Aug-94	5.0	5.4	7.2	6.8	0.4	<0.001	<0.001	0.156	0.323	0.594	0.357	0.359	0.839	0.334	2.962	64.9
80Y10	Aug-94	5.4	5.8	6.8	6.4	0.4	<0.001	<0.001	0.179	0.361	0.644	0.410	0.337	0.797	0.318	3.046	56.0
80Y9	Aug-94	5.8	6.2	6.4	6.0	0.4	<0.001	0.007	0.095	0.203	0.372	0.213	0.194	0.521	0.207	1.812	39.9
80Y8	Aug-94	6.2	6.6	6.0	5.6	0.4	<0.001	0.004	0.068	0.158	0.225	0.131	0.265	0.550	0.223	1.563	39.4
80Y7	Aug-94	6.6	7.0	5.6	5.2	0.4	<0.001	0.006	0.049	0.107	0.101	0.080	0.226	0.614	0.249	1.432	34.8
-	Aug-94	7.0	7.9	5.2	4.3	0.9	<0.001	0.003	0.030	0.065	0.072	0.053	0.143	0.382	0.149	0.898	20.3
80Y19	Aug-94	7.9	8.4	4.3	3.8	0.5	<0.001	<0.001	0.012	0.023	0.044	0.026	0.061	0.149	0.049	0.364	<10.0
80Y18	Aug-94	8.4	8.8	3.8	3.4	0.4	<0.001	<0.001	0.021	0.046	0.074	0.046	0.111	0.275	0.089	0.661	10.2
80Y17	Aug-94	8.8	9.2	3.4	3.0	0.4	<0.001	<0.001	0.021	0.049	0.074	0.049	0.106	0.282	0.098	0.679	<10.0
80Y16	Aug-94	9.2	9.6	3.0	2.6	0.4	<0.001	<0.001	0.025	0.053	0.095	0.057	0.098	0.269	0.099	0.696	<10.0

APPENDIX A (cont.)
GC/MS DATA FOR EGLIN AFB SOIL CORES

Sample ID	Date	Lo.int (ft)	Hi.int (ft)	Top.int (ft MSL)	Bot.int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80Y15	Aug-94	9.6	10.0	2.6	2.2	0.4	<0.001	<0.001	0.024	0.049	0.089	0.052	0.090	0.216	0.075	0.584	<10.0
80Y14	Aug-94	10.0	10.4	2.2	1.8	0.4	<0.001	<0.001	0.017	0.036	0.058	0.038	0.071	0.189	0.064	0.473	<10.0
80Z7	Aug-94	1.1	1.4	9.9	9.6	0.3	<0.001	0.007	<0.001	0.004	0.008	0.007	0.004	0.006	<0.001	0.036	<10.0
80Z6	Aug-94	1.4	1.8	9.6	9.2	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Z5	Aug-94	1.8	2.1	9.2	8.9	0.3	<0.001	0.008	<0.001	<0.001	0.008	<0.001	<0.001	0.007	<0.001	0.022	<10.0
80Z4	Aug-94	2.1	2.5	8.9	8.5	0.4	0.018	<0.001	0.022	0.040	0.057	<0.001	0.043	0.033	0.033	0.244	109.0
80Z3	Aug-94	2.5	2.8	8.5	8.2	0.3	0.011	0.063	2.320	4.200	7.490	0.161	7.940	11.200	5.710	39.095	5630.0
80Z2	Aug-94	2.8	3.2	8.2	7.8	0.4	0.009	0.041	5.080	8.740	16.600	0.191	17.000	29.700	13.800	91.161	6490.0
80Z1	Aug-94	3.2	3.5	7.8	7.5	0.3	<0.001	0.051	12.500	19.800	36.200	0.214	25.800	55.700	20.100	170.365	9160.0
80Z14	Aug-94	3.5	3.7	7.5	7.3	0.2	<0.001	0.025	0.784	1.350	2.440	0.216	1.850	4.250	1.670	12.585	574.0
80Z13	Aug-94	3.7	4.0	7.3	7.0	0.3	<0.001	0.012	1.110	1.930	3.690	0.284	2.490	5.940	2.200	17.656	800.0
80Z12	Aug-94	4.0	4.4	7.0	6.6	0.4	<0.001	<0.001	0.018	0.043	0.069	0.005	0.043	0.112	0.037	0.328	13.5
80Z11	Aug-94	4.4	4.8	6.6	6.2	0.4	<0.001	0.010	0.010	0.021	0.031	0.004	0.024	0.073	0.024	0.186	14.0
80Z10	Aug-94	4.8	5.2	6.2	5.8	0.4	<0.001	<0.001	0.004	0.007	0.013	<0.001	0.008	0.019	0.006	0.057	<10.0
80Z9	Aug-94	5.2	5.6	5.8	5.4	0.4	<0.001	<0.001	0.016	0.027	0.047	0.004	0.031	0.079	0.027	0.231	17.2
80Z8	Aug-94	5.6	6.0	5.4	5.0	0.4	<0.001	<0.001	0.037	0.061	0.110	0.009	0.072	0.176	0.064	0.529	25.3
80Z20	Aug-94	6.0	6.5	5.0	4.5	0.5	<0.001	<0.001	0.005	0.009	0.016	<0.001	0.015	0.036	0.014	0.095	<10.0
80Z19	Aug-94	6.5	6.9	4.5	4.1	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.025	0.010	0.044	<10.0
80Z18	Aug-94	6.9	7.3	4.1	3.7	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.024	0.008	0.042	<10.0
80Z17	Aug-94	7.3	7.7	3.7	3.3	0.4	<0.001	<0.001	<0.001	0.005	0.009	<0.001	0.013	0.034	0.013	0.073	<10.0
80Z16	Aug-94	7.7	8.1	3.3	2.9	0.4	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	0.006	0.012	0.005	0.028	<10.0
80Z15	Aug-94	8.1	8.5	2.9	2.5	0.4	<0.001	<0.001	0.009	0.015	0.022	<0.001	0.013	0.030	0.012	0.100	<10.0
80ZA6	Aug-94	2.5	2.7	9.5	9.3	0.2	<0.001	0.021	<0.001	<0.001	0.014	0.010	<0.001	0.011	<0.001	0.056	<10.0
80ZA5	Aug-94	2.7	3.2	9.3	8.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZA4	Aug-94	3.2	3.6	8.8	8.4	0.4	<0.001	0.012	<0.001	<0.001	<0.001	<0.001	<0.001	0.009	<0.001	0.021	950.0
80ZA3	Aug-94	3.6	4.1	8.4	7.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	0.074	0.463	<0.001	<0.001	0.537	5290.0
80ZA2	Aug-94	4.1	4.5	7.9	7.5	0.4	<0.001	0.012	0.011	0.017	0.069	0.021	5.040	1.440	1.750	8.359	4040.0
80ZA1	Aug-94	4.5	5.0	7.5	7.0	0.5	<0.001	0.004	<0.001	0.003	<0.001	<0.001	0.716	0.731	0.439	1.893	255.0
80ZA13	Aug-94	5.0	5.1	7.0	6.9	0.1	<0.001	0.026	<0.001	<0.001	<0.001	<0.001	0.016	0.061	0.033	0.136	<10.0
80ZA12	Aug-94	5.1	5.5	6.9	6.5	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.011	0.117	0.051	0.180	<10.0

APPENDIX A (cont.) GC/MS DATA FOR EGLIN AFB SOIL CORES

Sample ID	Date	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bot int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80ZB10	Aug-94	5.0	5.5	7.4	6.9	0.5	<0.001	0.008	0.025	0.192	0.212	0.024	2.080	3.320	2.620	8.480	596.0
80ZB9	Aug-94	5.5	6.0	6.9	6.4	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.093	0.104	0.073	0.270	11.3
80ZB8	Aug-94	6.0	6.5	6.4	5.9	0.5	<0.001	<0.001	0.006	0.017	0.027	<0.001	0.045	0.077	0.043	0.214	<10.0
80ZB7	Aug-94	6.5	7.0	5.9	5.4	0.5	<0.001	<0.001	0.018	0.062	0.103	0.007	0.077	0.215	0.097	0.580	12.7
80ZB6	Aug-94	7.0	7.5	5.4	4.9	0.5	<0.001	<0.001	0.004	0.014	0.019	0.005	0.077	0.112	0.056	0.253	<10.0
80ZB16	Aug-94	7.5	7.8	4.9	4.6	0.3	<0.001	<0.001	<0.001	0.006	0.007	<0.001	0.040	0.081	0.058	0.192	13.5
80ZB15	Aug-94	7.8	8.2	4.6	4.2	0.4	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	0.032	0.078	0.051	0.164	12.4
80ZB14	Aug-94	8.2	8.7	4.2	3.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.060	0.029	0.089	<10.0
80ZB13	Aug-94	8.7	9.1	3.7	3.3	0.4	<0.001	<0.001	<0.001	0.005	<0.001	0.004	<0.001	0.086	0.047	0.142	<10.0
80ZB12	Aug-94	9.1	9.6	3.3	2.8	0.5	<0.001	<0.001	<0.001	0.009	0.005	0.010	<0.001	0.108	0.053	0.184	<10.0
80ZB11	Aug-94	9.6	10.0	2.8	2.4	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.017	0.008	0.025	15.3
80ZC6	Aug-94	3.0	3.3	10.9	10.6	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZC5	Aug-94	3.3	3.7	10.6	10.2	0.4	<0.001	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	<10.0
80ZC4	Aug-94	3.7	4.2	10.2	9.7	0.5	<0.001	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	<10.0
80ZC3	Aug-94	4.2	4.6	9.7	9.3	0.4	<0.001	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZC2	Aug-94	4.6	5.1	9.3	8.8	0.5	<0.001	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<10.0
80ZC1	Aug-94	5.1	5.5	8.8	8.4	0.4	<0.001	0.021	<0.001	0.111	<0.001	<0.001	<0.001	<0.001	0.015	0.048	566.0
80ZC12	Aug-94	5.5	6.0	8.4	7.9	0.5	0.006	0.019	0.023	0.138	0.199	0.108	7.990	1.980	2.780	13.243	2780.0
80ZC11	Aug-94	6.0	6.4	7.9	7.5	0.4	<0.001	0.009	1.700	14.800	23.000	12.200	38.200	65.500	30.800	186.209	11000.0
80ZC10	Aug-94	6.4	6.8	7.5	7.1	0.4	<0.001	0.007	0.873	4.620	8.410	5.060	4.470	10.300	4.050	37.790	1050.0
80ZC9	Aug-94	6.8	7.2	7.1	6.7	0.4	<0.001	0.006	0.101	0.466	0.773	0.357	0.401	0.946	0.399	3.649	67.2
80ZC8	Aug-94	7.2	7.6	6.7	6.3	0.4	<0.001	<0.001	0.054	0.314	0.515	0.355	0.480	0.937	0.460	3.175	90.5
80ZC7	Aug-94	7.6	8.0	6.3	5.9	0.4	<0.001	0.004	0.069	0.399	0.670	0.443	0.549	1.050	0.518	3.702	104.0
80ZC18	Aug-94	8.0	8.5	5.9	5.4	0.5	<0.001	0.002	0.034	0.200	0.337	0.222	0.308	0.547	0.280	1.930	52.4
80ZC17	Aug-94	8.5	8.9	5.4	5.0	0.4	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	0.067	0.044	0.043	0.158	<10.0
80ZC16	Aug-94	8.9	9.3	5.0	4.6	0.4	<0.001	<0.001	<0.001	<0.001	0.005	0.004	0.059	0.050	0.051	0.169	<10.0
80ZC15	Aug-94	9.3	9.7	4.6	4.2	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.068	0.071	0.068	0.208	<10.0
80ZC14	Aug-94	9.7	10.1	4.2	3.8	0.4	<0.001	<0.001	<0.001	0.009	0.009	0.010	0.065	0.092	0.083	0.267	<10.0
80ZC13	Aug-94	10.1	10.5	3.8	3.4	0.4	<0.001	<0.001	0.005	0.036	0.042	0.048	0.091	0.146	0.115	0.483	<10.0
80ZD6	Aug-94	3.0	3.3	9.9	9.6	0.3	<0.001	0.009	<0.001	<0.001	<0.001	<0.001	<0.001	0.009	<0.001	0.018	<10.0
80ZD5	Aug-94	3.3	3.7	9.6	9.2	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZD4	Aug-94	3.7	4.2	9.2	8.7	0.5	<0.001	0.006	<0.001	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	0.010	<10.0
80ZD3	Aug-94	4.2	4.6	8.7	8.3	0.4	<0.001	0.007	<0.001	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	0.011	41.9
80ZD2	Aug-94	4.6	5.1	8.3	7.8	0.5	<0.001	0.007	<0.001	0.007	0.005	0.008	<0.001	<0.001	0.010	0.037	271.0
80ZD1	Aug-94	5.1	5.5	7.8	7.4	0.4	<0.001	0.021	0.012	0.045	0.005	<0.001	0.988	0.168	0.053	1.292	3560.0
80ZD12	Aug-94	5.5	5.6	7.4	7.3	0.1	<0.001	0.011	<0.001	<0.001	<0.001	<0.001	0.582	0.225	0.143	0.961	320.0
80ZD11	Aug-94	5.6	6.1	7.3	6.8	0.5	<0.001	<0.001	0.006	0.013	0.012	0.009	2.750	1.190	0.665	4.585	1270.0
80ZD10	Aug-94	6.1	6.6	6.8	6.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.052	0.016	0.028	0.097	36.2
80ZD9	Aug-94	6.6	7.1	6.3	5.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.034	0.013	0.018	0.064	29.3
80ZD8	Aug-94	7.1	7.5	5.8	5.4	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.034	0.010	0.018	0.061	16.1
80ZD7	Aug-94	7.5	8.0	5.4	4.9	0.5	<0.001	<0.001	<0.001	<0.001	0.003	0.004	0.043	0.018	0.022	0.090	15.8
80ZD17	Aug-94	8.0	8.5	4.9	4.4	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.030	0.022	0.012	0.064	19.5
80ZD16	Aug-94	8.5	9.0	4.4	3.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.021	0.020	0.011	0.052	<10.0
80ZD15	Aug-94	9.0	9.5	3.9	3.4	0.5	<0.001	<0.001	<0.001	0.005	0.007	0.004	0.023	0.029	0.016	0.084	<10.0
80ZD14	Aug-94	9.5	10.0	3.4	2.9	0.5	<0.001	<0.001	0.003	0.008	0.009	0.007	0.034	0.048	0.027	0.137	<10.0
80ZD13	Aug-94	10.0	10.5	2.9	2.4	0.5	<0.001	<0.001	0.005	0.015	0.020	0.015	0.067	0.082	0.050	0.254	<10.0
80ZE6	Aug-94	3.0	3.1	9.3	9.2	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0

APPENDIX A (cont.) **GC/MS DATA FOR EGLIN AFB SOIL CORES**

Sample ID	Date	Lo Int (ft)	Hi Int (ft)	Top Int (ft MSL)	Bot Int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80ZE5	Aug-94	3.1	3.6	9.2	8.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZE4	Aug-94	3.6	4.1	8.7	8.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZE3	Aug-94	4.1	4.6	8.2	7.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZE2	Aug-94	4.6	5.0	7.7	7.3	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZE1	Aug-94	5.0	5.5	7.3	6.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	0.004	0.009	<10.0
80ZE12	Aug-94	5.5	5.7	6.8	6.6	0.2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.050	0.022	0.046	0.114	<10.0
80ZE11	Aug-94	5.7	6.2	6.6	6.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.068	0.015	0.061	0.151	<10.0
80ZE10	Aug-94	6.2	6.6	6.1	5.7	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.068	0.015	0.055	0.138	<10.0
80ZE9	Aug-94	6.6	7.1	5.7	5.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.048	0.028	0.020	0.078	<10.0
80ZE8	Aug-94	7.1	7.5	5.2	4.8	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.029	0.036	0.018	0.106	<10.0
80ZE7	Aug-94	7.5	8.0	4.8	4.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.045	0.015	0.010	0.039	<10.0
80ZE16	Aug-94	8.0	8.2	4.3	4.1	0.2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.012	0.063	0.034	0.176	<10.0
80ZE17	Aug-94	8.7	9.1	3.6	3.2	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.059	0.144	0.070	0.429	<10.0
80ZE16	Aug-94	9.1	9.6	3.2	2.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.075	0.167	0.079	0.517	<10.0
80ZE15	Aug-94	9.6	10.0	2.7	2.3	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.017	0.042	0.021	0.088	<10.0
80ZE14	Aug-94	10.0	10.5	2.3	1.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	0.059	0.028	0.117	<10.0
80ZE13	Aug-94																
80ZF6	Aug-94	3.0	3.2	9.7	9.5	0.2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZF5	Aug-94	3.2	3.7	9.5	9.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZF4	Aug-94	3.7	4.1	9.0	8.6	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZF3	Aug-94	4.1	4.6	8.6	8.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZF2	Aug-94	4.6	5.0	8.1	7.7	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZF1	Aug-94	5.0	5.5	7.7	7.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZF12	Aug-94	5.5	5.8	7.2	6.9	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZF11	Aug-94	5.8	6.2	6.9	6.5	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZF10	Aug-94	6.2	6.7	6.5	6.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.019	0.008	0.019	0.046	<10.0
80ZF9	Aug-94	6.7	7.1	6.0	5.6	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.052	0.056	0.066	0.173	<10.0
80ZF8	Aug-94	7.1	7.6	5.6	5.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.061	0.031	0.051	0.143	<10.0
80ZF7	Aug-94	7.6	8.0	5.1	4.7	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.047	0.030	0.062	0.139	<10.0
80ZF18	Aug-94	8.0	8.3	4.7	4.4	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.034	0.018	0.014	0.066	<10.0
80ZF17	Aug-94	8.3	8.7	4.4	4.0	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.029	0.022	0.012	0.068	<10.0
80ZF16	Aug-94	8.7	9.2	4.0	3.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.034	0.018	0.014	0.066	<10.0
80ZF15	Aug-94	9.2	9.6	3.5	3.1	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.029	0.022	0.012	0.068	<10.0
80ZF14	Aug-94	9.6	10.1	3.1	2.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.041	0.016	0.016	0.088	<10.0
80ZF13	Aug-94	10.1	10.5	2.6	2.2	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.077	0.049	0.069	0.206	<10.0
80ZG5	Aug-94	2.0	2.5	11.2	10.7	0.5	<0.001	0.007	0.578	4.710	8.530	0.226	21.300	28.500	16.700	80.551	6560.0
80ZG4	Aug-94	2.5	3.0	10.7	10.2	0.5	<0.001	0.036	0.120	1.060	1.910	0.057	6.380	3.960	4.120	17.643	2030.0
80ZG3	Aug-94	3.0	3.5	10.2	9.7	0.5	<0.001	0.031	0.021	0.207	0.349	0.021	4.610	2.390	3.150	10.779	1580.0
80ZG2	Aug-94	3.5	4.0	9.7	9.2	0.5	<0.001	0.010	0.021	1.140	1.610	0.093	10.400	11.600	8.560	33.434	2750.0
80ZG1	Aug-94	4.0	4.5	9.2	8.7	0.5	<0.001	<0.001	0.058	4.300	6.160	0.140	20.300	26.400	18.000	75.358	5210.0
80ZG12	Aug-94	4.5	4.6	8.7	8.6	0.1	<0.001	0.103	3.620	8.910	17.100	0.136	15.700	29.800	14.800	90.186	3350.0
80ZG11	Aug-94	4.6	5.0	8.6	8.2	0.4	0.007	0.014	7.700	15.500	32.100	0.084	16.400	36.000	15.500	123.305	4900.0
80ZG10	Aug-94	5.0	5.4	8.2	7.8	0.4	0.019	0.044	30.200	57.500	128.000	0.272	41.900	114.000	39.600	411.535	10100.0
80ZG9	Aug-94	5.4	5.8	7.8	7.4	0.4	0.020	0.159	74.800	121.000	281.000	0.598	63.800	179.000	59.200	779.577	19700.0
80ZG8	Aug-94	5.8	6.2	7.4	7.0	0.4	<0.001	0.007	2.220	3.320	7.770	0.011	1.640	4.500	1.540	21.008	472.0
80ZG7	Aug-94	6.2	6.6	7.0	6.6	0.4	<0.001	0.005	0.790	1.140	2.420	0.007	0.428	1.170	0.432	6.393	79.6
80ZG6	Aug-94	6.6	7.0	6.6	6.2	0.4	<0.001	0.005	0.561	0.808	1.820	0.006	0.263	0.755	0.284	4.502	46.3
80ZG17	Aug-94	7.0	7.4	6.2	5.8	0.4	<0.001	0.007	0.461	0.614	1.390	<0.001	0.211	0.605	0.230	3.518	23.5

APPENDIX A (cont.) GC/MS DATA FOR EGLIN AFB SOIL CORES

Sample ID	Date	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bot int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80ZG16	Aug-94	7.4	8.0	5.8	5.2	0.6	<0.001	0.007	0.515	0.731	1.640	0.008	0.347	0.847	0.356	4.451	58.7
80ZG15	Aug-94	8.0	8.5	5.2	4.7	0.5	<0.001	0.011	0.679	0.947	1.970	0.007	0.463	1.120	0.463	5.665	78.0
80ZG14	Aug-94	8.5	9.0	4.7	4.2	0.5	<0.001	0.013	0.561	0.738	1.640	0.005	0.242	0.726	0.254	4.179	27.5
80ZG13	Aug-94	9.0	9.5	4.2	3.7	0.5	<0.001	0.008	0.425	0.532	1.160	<0.001	0.137	0.411	0.164	2.837	19.2
80ZH5	Aug-94	2.0	2.5	11.7	11.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZH4	Aug-94	2.5	3.0	11.2	10.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZH3	Aug-94	3.0	3.5	10.7	10.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZH2	Aug-94	3.5	4.0	10.2	9.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZH1	Aug-94	4.0	4.5	9.7	9.2	0.5	<0.001	0.011	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZH12	Aug-94	4.5	4.8	9.2	8.9	0.3	<0.001	0.011	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.011	<10.0
80ZH11	Aug-94	4.8	5.2	8.9	8.5	0.4	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<10.0
80ZH10	Aug-94	5.2	5.7	8.5	8.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZH9	Aug-94	5.7	6.1	8.0	7.6	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZH8	Aug-94	6.1	6.6	7.6	7.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZH7	Aug-94	6.6	7.0	7.1	6.7	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZH6	Aug-94	7.0	7.5	6.7	6.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Z15	Aug-94	2.5	3.0	11.4	10.9	0.5	<0.001	0.009	<0.001	0.006	0.010	0.006	<0.001	0.005	<0.001	0.035	<10.0
80Z14	Aug-94	3.0	3.5	10.9	10.4	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Z13	Aug-94	3.5	4.0	10.4	9.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Z12	Aug-94	4.0	4.5	9.9	9.4	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Z11	Aug-94	4.5	5.0	9.4	8.9	0.5	<0.001	0.010	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	<10.0
80Z12	Aug-94	5.0	5.2	8.9	8.7	0.2	<0.001	0.009	<0.001	0.008	<0.001	0.010	0.074	<0.001	0.034	0.134	326.0
80Z11	Aug-94	5.2	5.5	8.7	8.4	0.3	0.007	0.014	<0.001	0.060	0.069	0.025	2.100	0.296	0.340	2.622	2590.0
80Z10	Aug-94	5.5	5.9	8.4	8.0	0.4	<0.001	0.010	<0.001	0.065	<0.001	0.036	18.400	0.272	7.340	26.147	5150.0
80Z19	Aug-94	5.9	6.3	8.0	7.6	0.4	<0.001	0.013	<0.001	0.011	<0.001	0.007	4.230	0.272	2.250	6.783	925.0
80Z18	Aug-94	6.3	6.7	7.6	7.2	0.4	<0.001	<0.001	<0.001	0.011	<0.001	<0.001	0.014	<0.001	<0.001	0.014	13.6
80Z17	Aug-94	6.7	7.1	7.2	6.8	0.4	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.061	<0.001	0.032	0.095	11.8
80Z16	Aug-94	7.1	7.5	6.8	6.4	0.4	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	0.220	0.011	0.115	0.349	32.9
80Z16	Aug-94	2.5	2.8	11.4	11.1	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Z15	Aug-94	2.8	3.2	11.1	10.7	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Z14	Aug-94	3.2	3.7	10.7	10.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Z13	Aug-94	3.7	4.1	10.2	9.8	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Z12	Aug-94	4.1	4.6	9.8	9.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80Z11	Aug-94	4.6	5.0	9.3	8.9	0.4	<0.001	<0.001	<0.001	0.006	0.023	0.009	0.006	0.017	0.005	0.073	<10.0
80Z11	Aug-94	5.0	5.3	8.9	8.6	0.3	<0.001	0.025	0.014	0.058	0.045	0.029	1.750	0.094	0.266	2.280	3060.0
80Z12	Aug-94	5.3	5.7	8.6	8.2	0.4	0.009	0.021	0.389	1.540	2.800	1.210	22.900	21.600	13.300	63.748	7710.0
80Z11	Aug-94	5.7	6.0	8.2	7.9	0.3	<0.001	0.225	6.640	19.900	35.300	14.700	92.500	227.000	86.800	483.065	19700.0
80Z10	Aug-94	6.0	6.4	7.9	7.5	0.4	<0.001	0.315	10.400	23.900	51.200	20.600	46.300	127.000	45.300	325.015	10700.0
80Z19	Aug-94	6.4	6.7	7.5	7.2	0.3	<0.001	0.050	2.430	5.030	11.100	4.700	5.290	14.800	5.070	48.470	1460.0
80Z18	Aug-94	6.7	7.1	7.2	6.8	0.4	<0.001	0.009	0.574	1.110	1.890	1.270	0.866	2.240	0.915	8.874	196.0
80Z17	Aug-94	7.1	7.5	6.8	6.4	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	0.006	0.007	0.019	<10.0
80ZK4	May-95	1.5	2.0	10.4	9.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZK3	May-95	2.0	2.5	9.9	9.4	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZK2	May-95	2.5	3.0	9.4	8.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZK1	May-95	3.0	3.5	8.9	8.4	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZK10	May-95	3.5	3.6	8.4	8.3	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.035	<0.001	<0.001	0.035	<10.0

APPENDIX A (cont.) GC/MS DATA FOR EGLIN AFB SOIL CORES

Sample ID	Date	Lo Int (ft)	Hi Int (ft)	Top Int (ft MSL)	Bot Int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80ZK9	May-95	3.6	4.1	8.3	7.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1320.0
80ZK8	May-95	4.1	4.5	7.8	7.4	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.009	<0.001	0.009	561.0
80ZK7	May-95	4.5	5.0	7.4	6.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.028	<0.001	<0.001	0.028	65.2
80ZK6	May-95	5.0	5.5	6.9	6.4	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZK5	May-95	5.5	6.0	6.4	5.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZK15	May-95	6.0	6.3	5.9	5.6	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZK14	May-95	6.3	6.7	5.6	5.2	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZK13	May-95	6.7	7.2	5.2	4.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZK12	May-95	7.2	7.6	4.7	4.3	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZK11	May-95	7.6	8.0	4.3	3.9	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZL5	May-95	1.0	1.5	12.1	11.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZL4	May-95	1.5	2.0	11.6	11.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZL3	May-95	2.0	2.5	11.1	10.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZL2	May-95	2.5	3.0	10.6	10.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZL1	May-95	3.0	3.5	10.1	9.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	19.1
80ZL10	May-95	3.5	4.0	9.6	9.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	127.0
80ZL9	May-95	4.0	4.5	9.1	8.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.021	0.010	0.030	160.0
80ZL8	May-95	4.5	5.0	8.6	8.1	0.5	<0.001	0.148	0.559	1.110	1.850	0.856	8.060	8.400	4.850	25.833	3940.0
80ZL7	May-95	5.0	5.5	8.1	7.6	0.5	<0.001	0.477	4.220	7.940	14.900	8.730	20.300	40.300	15.600	112.467	5960.0
80ZL6	May-95	5.5	6.0	7.6	7.1	0.5	<0.001	2.470	32.000	53.200	112.000	68.800	37.700	88.900	31.200	426.270	8640.0
80ZL13	May-95	6.0	6.5	7.1	6.6	0.5	<0.001	1.190	5.380	8.320	17.700	9.870	5.340	13.400	4.020	65.220	1040.0
80ZL12	May-95	6.5	7.0	6.6	6.1	0.5	<0.001	0.049	0.549	0.745	1.570	0.026	0.252	0.576	0.272	4.039	48.9
80ZL11	May-95	7.0	7.5	6.1	5.6	0.5	<0.001	0.194	0.610	0.814	1.700	0.250	0.321	0.741	0.333	4.963	45.6
80ZM4	May-95	1.5	2.0	11.0	10.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZM3	May-95	2.0	2.5	10.5	10.0	0.5	<0.001	<0.001	0.032	0.468	0.242	0.078	5.970	8.730	6.240	21.760	2870.0
80ZM2	May-95	2.5	3.0	10.0	9.5	0.5	<0.001	<0.001	0.051	0.268	0.100	0.091	5.480	8.930	0.917	15.836	4250.0
80ZM1	May-95	3.0	3.5	9.5	9.0	0.5	<0.001	<0.001	0.028	0.283	0.076	0.084	2.710	7.950	5.150	16.282	3210.0
80ZM9	May-95	3.5	4.0	9.0	8.5	0.5	<0.001	<0.001	0.042	0.102	0.040	0.038	0.504	9.080	1.170	10.975	3340.0
80ZM8	May-95	4.0	4.5	8.5	8.0	0.5	<0.001	<0.001	4.330	6.140	8.260	<0.001	9.420	31.800	0.888	60.838	3580.0
80ZM7	May-95	4.5	5.0	8.0	7.5	0.5	0.025	0.070	31.400	40.400	86.300	0.020	35.500	83.100	28.800	305.616	7930.0
80ZM6	May-95	5.0	5.5	7.5	7.0	0.5	0.066	0.053	23.900	28.100	64.000	0.015	15.700	38.300	14.700	184.834	3710.0
80ZM5	May-95	5.5	6.0	7.0	6.5	0.5	0.063	0.028	1.710	1.900	4.790	0.294	0.824	2.060	0.863	12.532	225.0
80ZM16	May-95	6.0	6.2	6.5	6.3	0.2	0.049	<0.001	7.120	7.970	19.200	0.014	4.500	10.800	4.110	53.762	1210.0
80ZM15	May-95	6.2	6.6	6.3	5.9	0.4	0.020	<0.001	0.267	0.290	0.789	<0.001	0.125	0.281	0.127	1.899	<10.0
80ZM14	May-95	6.6	6.9	5.9	5.6	0.3	0.015	<0.001	0.199	0.249	0.462	<0.001	0.104	0.257	0.105	1.391	<10.0
80ZM13	May-95	6.9	7.3	5.6	5.2	0.4	0.011	<0.001	0.097	0.190	0.313	<0.001	0.070	0.180	0.080	0.941	<10.0
80ZM12	May-95	7.3	7.7	5.2	4.8	0.4	0.013	<0.001	0.071	0.170	0.240	<0.001	0.055	0.169	0.062	0.780	<10.0
80ZM11	May-95	7.7	8.1	4.8	4.4	0.4	0.011	<0.001	0.082	0.209	0.255	0.033	0.073	0.187	0.086	0.935	<10.0
80ZM10	May-95	8.1	8.5	4.4	4.0	0.4	0.008	<0.001	0.067	0.215	0.155	0.078	0.088	0.237	0.112	0.959	11.7
80ZN6	May-95	2.0	2.2	9.5	9.3	0.2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZN5	May-95	2.2	2.7	9.3	8.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZN4	May-95	2.7	3.1	8.8	8.4	0.4	<0.001	<0.001	0.046	0.130	0.049	0.055	0.220	0.404	0.177	1.081	4510.0
80ZN3	May-95	3.1	3.6	8.4	7.9	0.5	<0.001	<0.001	0.183	0.622	0.388	0.289	13.200	29.000	10.300	53.982	9870.0
80ZN2	May-95	3.6	4.0	7.9	7.5	0.4	<0.001	0.015	0.795	2.760	0.967	2.060	12.000	27.900	11.800	58.297	1620.0
80ZN1	May-95	4.0	4.5	7.5	7.0	0.5	<0.001	<0.001	0.053	0.153	0.041	0.129	0.220	0.625	0.362	1.584	28.0
80ZN12	May-95	4.5	4.9	7.0	6.6	0.4	<0.001	<0.001	0.039	0.107	0.027	0.099	0.116	0.431	0.269	1.088	11.0
80ZN11	May-95	4.9	5.3	6.6	6.2	0.4	<0.001	<0.001	0.039	0.107	0.027	0.099	0.116	0.431	0.269	1.088	11.0

APPENDIX A (cont.) GC/MS DATA FOR EGLIN AFB SOIL CORES

Sample ID	Date	Lo Int (ft)	Hi Int (ft)	Top Int (ft MSL)	Bot Int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80ZN10	May-95	5.3	5.7	6.2	5.8	0.4	<0.001	<0.001	0.024	0.064	0.022	0.048	0.039	0.237	0.106	0.540	<10.0
80ZN9	May-95	5.7	6.1	5.8	5.4	0.4	<0.001	<0.001	0.036	0.074	0.031	0.049	0.061	0.161	0.088	0.501	<10.0
80ZN8	May-95	6.1	6.5	5.4	5.0	0.4	<0.001	0.007	0.054	0.079	0.032	0.069	0.105	0.258	0.148	0.752	<10.0
80ZN7	May-95	6.5	7.0	5.0	4.5	0.5	<0.001	<0.001	0.011	0.021	<0.001	0.030	0.069	0.240	0.144	0.515	<10.0
80ZN17	May-95	7.0	7.2	4.5	4.3	0.2	<0.001	<0.001	<0.001	0.012	<0.001	0.011	0.068	0.268	0.116	0.475	<10.0
80ZN16	May-95	7.2	7.6	4.3	3.9	0.4	<0.001	<0.001	<0.001	0.012	<0.001	0.011	0.095	0.289	0.154	0.561	<10.0
80ZN15	May-95	7.6	8.0	3.9	3.5	0.4	<0.001	<0.001	<0.001	0.006	<0.001	<0.001	0.079	0.256	0.126	0.467	<10.0
80ZN14	May-95	8.0	8.4	3.5	3.1	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.054	0.232	0.099	0.385	<10.0
80ZN13	May-95	8.4	8.8	3.1	2.7	0.4	<0.001	<0.001	0.005	0.014	0.004	0.014	0.050	0.272	0.187	0.545	<10.0
80ZO5	May-95	1.5	1.9	9.5	9.1	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZO4	May-95	1.9	2.3	9.1	8.7	0.4	<0.001	0.029	0.042	0.052	0.008	0.050	0.107	0.013	0.150	0.451	881.0
80ZO3	May-95	2.3	2.7	8.7	8.3	0.4	0.006	0.066	0.043	0.077	0.096	0.135	0.755	0.059	0.563	1.799	3180.0
80ZO2	May-95	2.7	3.1	8.3	7.9	0.4	<0.001	0.078	0.558	1.320	3.010	2.010	8.560	11.400	7.600	34.536	4700.0
80ZO1	May-95	3.1	3.5	7.9	7.5	0.4	<0.001	0.033	2.530	6.230	12.000	6.360	37.100	99.900	32.100	195.253	9490.0
80ZO11	May-95	3.5	3.9	7.5	7.1	0.4	<0.001	0.025	0.630	1.580	2.620	1.030	13.000	29.300	11.900	60.085	2610.0
80ZO10	May-95	3.9	4.3	7.1	6.7	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.009	0.146	0.072	0.228	15.1
80ZO9	May-95	4.3	4.7	6.7	6.3	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.056	0.287	0.091	0.434	15.5
80ZO8	May-95	4.7	5.1	6.3	5.9	0.4	<0.001	0.008	<0.001	<0.001	0.006	<0.001	0.169	0.571	0.124	0.877	31.9
80ZO7	May-95	5.1	5.5	5.9	5.5	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.108	0.028	0.136	15.4
80ZO6	May-95	5.5	6.0	5.5	5.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.040	<0.001	0.040	<10.0
80ZO16	May-95	6.0	6.4	5.0	4.6	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	0.020	<0.001	0.027	<10.0
80ZO15	May-95	6.4	6.8	4.6	4.2	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.014	<0.001	<0.001	0.014	<10.0
80ZO14	May-95	6.8	7.2	4.2	3.8	0.4	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	0.010	0.010	0.008	0.035	<10.0
80ZO13	May-95	7.2	7.6	3.8	3.4	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	0.005	<10.0
80ZO12	May-95	7.6	8.0	3.4	3.0	0.4	<0.001	<0.001	0.005	<0.001	<0.001	0.008	0.013	0.015	0.014	0.055	<10.0
80ZP4	May-95	1.5	2.0	10.8	10.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZP3	May-95	2.0	2.5	10.3	9.8	0.5	<0.001	0.008	0.008	0.010	0.017	0.008	<0.001	0.009	<0.001	0.059	<10.0
80ZP2	May-95	2.5	3.0	9.8	9.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZP1	May-95	3.0	3.5	9.3	8.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZP9	May-95	3.5	4.0	8.8	8.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.160	0.509	0.246	1.915	2420.0
80ZP8	May-95	4.0	4.5	8.3	7.8	0.5	<0.001	<0.001	0.038	0.433	0.352	0.192	27.300	40.800	14.000	83.115	11900.0
80ZP7	May-95	4.5	5.0	7.8	7.3	0.5	<0.001	0.017	0.014	0.467	0.137	0.071	6.490	13.300	5.380	25.876	1740.0
80ZP6	May-95	5.0	5.5	7.3	6.8	0.5	<0.001	<0.001	0.006	0.081	0.010	0.014	0.436	1.230	0.494	2.271	97.3
80ZP5	May-95	5.5	6.0	6.8	6.3	0.5	<0.001	<0.001	<0.001	0.048	0.007	0.011	0.176	0.584	0.204	1.030	42.2
80ZP13	May-95	6.0	6.5	6.3	5.8	0.5	<0.001	<0.001	0.007	0.008	<0.001	<0.001	0.092	0.286	0.117	0.509	11.2
80ZP12	May-95	6.5	7.0	5.8	5.3	0.5	<0.001	<0.001	<0.001	0.014	<0.001	<0.001	0.095	0.220	0.097	0.386	<10.0
80ZP11	May-95	7.0	7.5	5.3	4.8	0.5	<0.001	<0.001	<0.001	0.036	<0.001	0.007	0.054	0.274	0.116	0.488	<10.0
80ZP10	May-95	7.5	8.0	4.8	4.3	0.5	<0.001	<0.001	<0.001	0.013	<0.001	<0.001	0.062	0.269	0.140	0.484	10.9
80ZQ5	May-95	1.3	1.8	11.0	10.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZQ4	May-95	1.8	2.2	10.5	10.1	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZQ3	May-95	2.2	2.7	10.1	9.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZQ2	May-95	2.7	3.1	9.6	9.2	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZQ1	May-95	3.1	3.5	9.2	8.8	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZQ11	May-95	3.5	3.7	8.8	8.6	0.2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.105	0.019	0.124	40.4
80ZQ10	May-95	3.7	4.2	8.6	8.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.023	0.023	664.0
80ZQ9	May-95	4.2	4.6	8.1	7.7	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.152	2.920	0.292	3.364	9730.0
80ZQ8	May-95	4.6	5.1	7.7	7.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.225	24.800	5.150	30.175	7230.0

APPENDIX A (cont.) **GC/MS DATA FOR EGLIN AFB SOIL CORES**

Sample ID	Date	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bot int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MYXL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80ZQ7	May-95	5.1	5.5	7.2	6.8	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.022	4.530	1.270	5.822	777.0
80ZQ6	May-95	5.5	6.0	6.8	6.3	0.5	<0.001	<0.001	0.005	0.036	<0.001	0.005	<0.001	0.221	0.128	0.395	22.2
80ZQ16	May-95	6.0	6.2	6.3	6.1	0.2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.103	0.055	0.158	<10.0
80ZQ15	May-95	6.2	6.6	6.1	5.7	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.150	0.084	0.234	<10.0
80ZQ14	May-95	6.6	7.0	5.7	5.3	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.120	0.065	0.185	<10.0
80ZQ13	May-95	7.0	7.4	5.3	4.9	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	0.071	0.030	0.107	<10.0
80ZQ12	May-95	7.4	7.8	4.9	4.5	0.4	<0.001	<0.001	<0.001	0.006	<0.001	<0.001	<0.001	0.170	0.119	0.295	<10.0
80ZR5	May-95	1.3	1.8	10.9	10.4	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZR4	May-95	1.8	2.2	10.4	10.0	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZR3	May-95	2.2	2.7	10.0	9.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZR2	May-95	2.7	3.1	9.5	9.1	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZR1	May-95	3.1	3.5	9.1	8.7	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZR11	May-95	3.5	3.8	8.7	8.4	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	214.0
80ZR10	May-95	3.8	4.2	8.4	8.0	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	0.078	<0.001	0.088	4990.0
80ZR9	May-95	4.2	4.7	8.0	7.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.965	0.404	1.369	4990.0
80ZR8	May-95	4.7	5.1	7.5	7.1	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.035	0.016	0.051	118.0
80ZR7	May-95	5.1	5.6	7.1	6.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.019	<0.001	0.019	22.5
80ZR6	May-95	5.6	6.0	6.6	6.2	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.015	<0.001	0.015	14.0
80ZR15	May-95	6.0	6.4	6.2	5.8	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.030	<0.001	0.030	<10.0
80ZR14	May-95	6.4	6.9	5.8	5.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.049	0.009	0.058	<10.0
80ZR13	May-95	6.9	7.3	5.3	4.9	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.055	0.011	0.065	<10.0
80ZR12	May-95	7.3	7.8	4.9	4.4	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.037	0.015	0.052	<10.0
80ZS5	May-95	1.0	1.5	10.8	10.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZS4	May-95	1.5	2.0	10.3	9.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZS3	May-95	2.0	2.5	9.8	9.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZS2	May-95	2.5	3.0	9.3	8.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	816.0
80ZS1	May-95	3.0	3.5	8.8	8.3	0.5	<0.001	0.012	<0.001	0.050	0.040	0.019	0.012	0.021	0.013	0.168	816.0
80ZS10	May-95	3.5	4.0	8.3	7.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.045	2.760	1.270	4.075	6370.0
80ZS9	May-95	4.0	4.5	7.8	7.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.083	0.050	0.133	59.0
80ZS8	May-95	4.5	5.0	7.3	6.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	<0.001	0.008	<10.0
80ZS7	May-95	5.0	5.5	6.8	6.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.019	0.011	0.031	29.0
80ZS6	May-95	5.5	6.0	6.3	5.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.018	0.055	0.033	0.106	23.6
80ZS16	May-95	6.0	6.4	5.8	5.4	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.022	0.035	0.021	0.079	<10.0
80ZS15	May-95	6.4	6.8	5.4	5.0	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.030	0.031	0.025	0.085	<10.0
80ZS14	May-95	6.8	7.2	5.0	4.6	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.016	0.014	0.012	0.042	<10.0
80ZS13	May-95	7.2	7.6	4.6	4.2	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	0.006	0.014	<10.0
80ZS12	May-95	7.6	8.0	4.2	3.8	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZS11	May-95	8.0	8.4	3.8	3.4	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZT5	May-95	2.5	3.0	9.9	9.4	0.5	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	<0.001	<0.001	<0.001	0.006	<10.0
80ZT4	May-95	3.0	3.5	9.4	8.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZT3	May-95	3.5	4.0	8.9	8.4	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	182.0
80ZT2	May-95	4.0	4.5	8.4	7.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	3430.0
80ZT1	May-95	4.5	5.0	7.9	7.4	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	4.760	0.146	2.090	6.996	11000.0
80ZT10	May-95	5.0	5.5	7.4	6.9	0.5	<0.001	<0.001	<0.001	0.016	0.010	0.014	1.270	0.239	0.707	3.046	245.0
80ZT9	May-95	5.5	6.0	6.9	6.4	0.5	<0.001	<0.001	<0.001	0.010	0.010	<0.001	0.124	0.246	0.163	0.545	20.2
80ZT8	May-95	6.0	6.5	6.4	5.9	0.5	<0.001	<0.001	0.011	0.021	0.033	<0.001	0.113	0.246	0.185	0.609	19.0
80ZT7	May-95	6.5	7.0	5.9	5.4	0.5	<0.001	<0.001	<0.001	0.027	0.036	0.034	0.197	0.241	0.158	0.693	13.9

APPENDIX A (cont.) GC/MS DATA FOR EGLIN AFB SOIL CORES

Sample ID	Date	Lo int (ft)	Hi int (ft)	Top int (ft MSL)	Bot int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80ZT6	May-95	7.0	7.5	5.4	4.9	0.5	<0.001	<0.001	<0.001	0.015	0.020	0.008	0.111	0.169	0.134	0.457	12.5
80ZT14	May-95	7.5	7.9	4.9	4.5	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.051	0.132	0.123	0.306	<10.0
80ZT13	May-95	7.9	8.3	4.5	4.1	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.045	0.119	0.117	0.281	<10.0
80ZT12	May-95	8.3	8.7	4.1	3.7	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.030	0.102	0.057	0.188	<10.0
80ZT11	May-95	8.7	9.1	3.7	3.3	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.055	0.058	0.112	<10.0
80ZU5	May-95	3.0	3.5	10.0	9.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZU4	May-95	3.5	4.0	9.5	9.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZU3	May-95	4.0	4.5	9.0	8.5	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	731.0
80ZU2	May-95	4.5	5.0	8.5	8.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.210	<0.001	<0.001	1.259	4150.0
80ZU1	May-95	5.0	5.5	8.0	7.5	0.5	<0.001	<0.001	<0.001	0.100	0.105	0.048	40.000	12.100	9.770	62.166	9320.0
80ZU10	May-95	5.5	6.0	7.5	7.0	0.5	<0.001	<0.001	0.009	0.032	0.052	0.080	0.177	0.260	0.177	0.787	<10.0
80ZU9	May-95	6.0	6.5	7.0	6.5	0.5	<0.001	<0.001	0.043	0.137	0.274	0.333	0.114	0.227	0.162	1.290	<10.0
80ZU8	May-95	6.5	7.0	6.5	6.0	0.5	<0.001	<0.001	0.041	0.143	0.273	0.309	0.105	0.144	0.126	1.141	<10.0
80ZU7	May-95	7.0	7.5	6.0	5.5	0.5	<0.001	<0.001	0.044	0.158	0.313	0.358	0.121	0.181	0.158	1.333	<10.0
80ZU6	May-95	7.5	8.0	5.5	5.0	0.5	<0.001	<0.001	0.044	0.153	0.298	0.328	0.112	0.213	0.132	1.280	<10.0
80ZU14	May-95	8.0	8.4	5.0	4.6	0.4	<0.001	<0.001	0.006	0.029	0.050	0.033	0.070	0.144	0.074	0.405	<10.0
80ZU13	May-95	8.4	8.8	4.6	4.2	0.4	<0.001	<0.001	<0.001	0.008	0.030	0.007	0.088	0.139	0.081	0.337	<10.0
80ZU12	May-95	8.8	9.2	4.2	3.8	0.4	<0.001	<0.001	<0.001	<0.001	0.008	<0.001	0.074	0.114	0.069	0.265	<10.0
80ZU11	May-95	9.2	9.6	3.8	3.4	0.4	<0.001	<0.001	<0.001	0.065	0.011	0.008	0.076	0.113	0.085	0.357	<10.0
80ZV5	May-95	3.0	3.5	10.3	9.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZV4	May-95	3.5	4.0	9.8	9.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZV3	May-95	4.0	4.5	9.3	8.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.033	0.018	<0.001	0.051	218.0
80ZV2	May-95	4.5	5.0	8.8	8.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	13.900	1.410	1.230	16.540	2870.0
80ZV1	May-95	5.0	5.5	8.3	7.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	2.900	0.575	0.922	4.407	580.0
80ZV11	May-95	5.5	5.8	7.8	7.5	0.3	<0.001	0.010	<0.001	<0.001	<0.001	<0.001	0.114	0.020	0.021	0.155	16.4
80ZV10	May-95	5.8	6.3	7.5	7.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.039	<0.001	<0.001	0.039	<10.0
80ZV9	May-95	6.3	6.7	7.0	6.6	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.045	<0.001	0.013	0.065	<10.0
80ZV8	May-95	6.7	7.2	6.6	6.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.055	0.009	0.014	0.078	<10.0
80ZV7	May-95	7.2	7.6	6.1	5.7	0.4	<0.001	<0.001	<0.001	0.005	0.008	<0.001	0.107	0.097	0.096	0.314	<10.0
80ZV6	May-95	7.6	8.0	5.7	5.3	0.4	<0.001	<0.001	<0.001	0.006	0.009	<0.001	0.079	0.169	0.119	0.382	<10.0
80ZV14	May-95	8.0	8.5	5.3	4.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.102	0.152	0.134	0.388	<10.0
80ZV13	May-95	8.5	9.0	4.8	4.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.091	0.090	0.084	0.265	<10.0
80ZV12	May-95	9.0	9.5	4.3	3.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZW4	May-95	3.5	4.0	9.4	8.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	53.8
80ZW3	May-95	4.0	4.5	8.9	8.4	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.609	<0.001	0.089	0.089	2060.0
80ZW2	May-95	4.5	5.0	8.4	7.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	11.100	0.972	0.744	1.374	5330.0
80ZW1	May-95	5.0	5.5	7.9	7.4	0.5	<0.001	0.008	0.033	0.118	0.081	0.054	0.116	0.065	0.800	13.166	7340.0
80ZW10	May-95	5.5	5.8	7.4	7.1	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.355	0.065	0.044	0.464	96.0
80ZW9	May-95	5.8	6.3	7.1	6.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.117	0.039	0.011	0.167	<10.0
80ZW8	May-95	6.3	6.7	6.6	6.2	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.078	0.031	0.020	0.129	<10.0
80ZW7	May-95	6.7	7.2	6.2	5.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.072	0.022	0.028	0.122	<10.0
80ZW6	May-95	7.2	7.6	5.7	5.3	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.040	0.008	0.007	0.056	<10.0
80ZW5	May-95	7.6	8.0	5.3	4.9	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.056	<0.001	0.015	0.071	<10.0
80ZW14	May-95	8.0	8.2	4.9	4.7	0.2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.084	0.015	0.015	0.114	<10.0
80ZW13	May-95	8.2	8.6	4.7	4.3	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.086	0.014	0.010	0.091	<10.0
80ZW12	May-95	8.6	9.0	4.3	3.9	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.061	0.013	<0.001	0.074	<10.0
80ZW11	May-95	9.0	9.4	3.9	3.5	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0

APPENDIX A (cont.) **GC/MS DATA FOR EGLIN AFB SOIL CORES**

Sample ID	Date	Lo Int (ft)	Hi Int (ft)	Top Int (ft MSL)	Bot Int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80ZX4	May-95	3.5	4.0	9.8	9.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZX3	May-95	4.0	4.5	9.3	8.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZX2	May-95	4.5	5.0	8.8	8.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZX1	May-95	5.0	5.5	8.3	7.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.009	<0.001	0.009	1450.0
80ZX9	May-95	5.5	6.0	7.8	7.3	0.5	<0.001	0.030	<0.001	<0.001	<0.001	<0.001	24.600	17.400	15.700	57.730	3770.0
80ZX8	May-95	6.0	6.5	7.3	6.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.572	0.508	0.438	1.518	73.8
80ZX7	May-95	6.5	7.0	6.8	6.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.122	0.057	0.121	0.423	<10.0
80ZX6	May-95	7.0	7.5	6.3	5.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.059	0.016	0.034	0.108	<10.0
80ZX5	May-95	7.5	8.0	5.8	5.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.036	<0.001	<0.001	0.036	<10.0
80ZX12	May-95	8.0	8.7	5.3	4.6	0.7	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.025	<0.001	<0.001	0.025	<10.0
80ZX11	May-95	8.7	9.2	4.6	4.1	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.047	0.007	0.009	0.063	<10.0
80ZX10	May-95	9.2	9.7	4.1	3.6	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZY5	May-95	3.0	3.5	9.7	9.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZY4	May-95	3.5	4.0	9.2	8.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	183.0
80ZY3	May-95	4.0	4.5	8.7	8.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.116	0.799	0.814	1.729	2050.0
80ZY2	May-95	4.5	5.0	8.2	7.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	10.100	1.800	0.312	12.212	6270.0
80ZY1	May-95	5.0	5.5	7.7	7.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.133	0.064	0.076	0.273	5420.0
80ZY10	May-95	5.5	6.0	7.2	6.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.108	0.031	0.045	0.185	13.4
80ZY9	May-95	6.0	6.5	6.7	6.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.057	<0.001	<0.001	0.057	<10.0
80ZY8	May-95	6.5	7.0	6.2	5.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.014	<0.001	<0.001	0.029	<10.0
80ZY7	May-95	7.0	7.5	5.7	5.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	0.019	<10.0
80ZY6	May-95	7.5	8.0	5.2	4.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZY14	May-95	8.0	8.5	4.7	4.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZY13	May-95	8.5	9.0	4.2	3.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	<0.001	0.006	<10.0
80ZY12	May-95	9.0	9.5	3.7	3.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	<0.001	0.006	0.013	<10.0
80ZY11	May-95	9.5	10.0	3.2	2.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZZ5	May-95	3.0	3.5	9.3	8.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZZ4	May-95	3.5	4.0	8.8	8.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZZ3	May-95	4.0	4.5	8.3	7.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZZ2	May-95	4.5	5.0	7.8	7.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	<0.001	<0.001	0.008	<10.0
80ZZ1	May-95	5.0	5.5	7.3	6.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZZ10	May-95	5.5	6.0	6.8	6.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.019	<0.001	<0.001	0.019	<10.0
80ZZ9	May-95	6.0	6.5	6.3	5.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.023	<0.001	<0.001	<0.001	<10.0
80ZZ8	May-95	6.5	7.0	5.8	5.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.033	0.018	<0.001	0.065	<10.0
80ZZ7	May-95	7.0	7.5	5.3	4.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.032	0.094	0.108	0.234	<10.0
80ZZ6	May-95	7.5	8.0	4.8	4.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.037	0.086	0.106	0.229	<10.0
80ZZ14	May-95	8.0	8.5	4.3	3.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.050	0.094	0.112	0.256	<10.0
80ZZ13	May-95	8.5	9.0	3.8	3.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.081	0.069	0.080	0.231	<10.0
80ZZ12	May-95	9.0	9.5	3.3	2.8	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZZ11	May-95	9.5	10.0	2.8	2.3	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZZA5	May-95	3.0	3.5	9.7	9.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZZA4	May-95	3.5	4.0	9.2	8.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZZA3	May-95	4.0	4.5	8.7	8.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZZA2	May-95	4.5	5.0	8.2	7.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZZA1	May-95	5.0	5.5	7.7	7.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZZA10	May-95	5.5	6.0	7.2	6.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0

APPENDIX A (cont.) GC/MS DATA FOR EGLIN AFB SOIL CORES

Sample ID	Date	Lo.int (ft)	Hi.int (ft)	Top.int (ft MSL)	Bot.int (ft MSL)	Int (ft)	BZ (mg/kg)	TOL (mg/kg)	ETBZ (mg/kg)	PXYL (mg/kg)	MXYL (mg/kg)	OXYL (mg/kg)	MESIT (mg/kg)	PSCU (mg/kg)	TMB (mg/kg)	BTEXTMB (mg/kg)	TPH (as JP-4) (mg/kg)
80ZZA9	May-95	6.0	6.5	6.7	6.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0
80ZZA8	May-95	6.5	7.0	6.2	5.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026	<0.001	<0.001	0.026	<10.0
80ZZA7	May-95	7.0	7.5	5.7	5.2	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.033	<0.001	<0.001	0.033	<10.0
80ZZA6	May-95	7.5	8.0	5.2	4.7	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.039	0.010	0.018	0.067	<10.0
80ZZA16	May-95	8.0	8.3	4.7	4.4	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.020	0.034	0.077	0.131	<10.0
80ZZA15	May-95	8.3	8.8	4.4	3.9	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.049	0.013	0.030	0.093	<10.0
80ZZA14	May-95	8.8	9.2	3.9	3.5	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.040	<0.001	<0.001	0.040	<10.0
80ZZA13	May-95	9.2	9.7	3.5	3.0	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.009	<0.001	<0.001	0.009	<10.0
80ZZA12	May-95	9.7	10.1	3.0	2.6	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.035	<0.001	<0.001	0.035	<10.0
80ZZA11	May-95	10.1	10.5	2.6	2.2	0.4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10.0

APPENDIX B OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

Date	Background Rain Gauge (in)	Weather	Comments	Nitrate Cell				Volume Water Added to Stock Tank (gal)
				Totalizer (gallons)	Pressure (psi)	Cell Flow Rate (GPM)	Mass KNO3 Added to Stock Tank (lbs)	
3/30/94 17:00	0.00		Background sampling. Rice personnel took other water levels.					500
4/1/94 8:30	0.00		Mixed stock solutions				150	
4/1/94 2:30	0.00		Started system with all sprinklers	3,660				
4/1/94 19:30	0.00		Shut down system due to problems					
4/2/94 8:30	0.00		Rice personnel took water levels					
4/3/94 8:45	0.00		Rice personnel took water levels					
4/4/94 16:00	0.00		Started system with all sprinklers, after emptying and then refilling mix tanks	9,111				
4/4/94 17:00	0.00		Shut down system due to problems	10,200				
4/5/94 14:40	0.00		Tested peristaltic pump; started up again with all sprinklers alternating	10,200				
4/5/94 19:00	0.00		Empty rain gauges, left system running overnight	12,820				
4/6/94 7:00	0.00		System had shut down overnight due to flow imbalances; plumbed in peristaltic pump	15,440		11.1		
4/6/94 17:30	0.00		Restart system with center/side sprinklers only	20,732		10.8		
4/7/94 14:00	0.00		System had shut down overnight due to flow imbalances; restarted using booster pump	32,960				
4/8/94 0:30	0.00		Midnight check, system about to shut down. Reset tank flows. Forgot to turn CI stock back on.	36,730				
4/8/94 8:30	0.00		System on and running fine, turned back on CI stock flow.	42,150				
4/8/94 18:30	0.00		System on	48,820		11.1		
4/9/94 7:30	0.00		System on	51,710				
4/9/94 13:15	0.00	Cloudy, light east wind	System on; replaced burned-out pump. Stocks off for about one hour.	57,420	48	11.1		
4/9/94 20:10	0.00	60°F, cool, breezy	System still on; SRH left for Ada	61,220				
4/10/94 15:40	0.00	75°F, clear, 10 mph east wind	System on	65,980	44	11.1		
4/11/94 9:20	0.00	70°F, clear, windy	System on	78,570	43	11.1		
4/12/94 13:00	0.00	70°F, cloudy, breezy	Pump fixed and system restarted at 10:30	90,280	46	10.9		
4/13/94 8:50	0.95	67°F, cloudy, rainy	System on. Everything okay at first, but then had to shut down at 17:00 due to pump leak.	94,840	49	11.2		
4/14/94 9:20	0.01	70°F, cloudy	System on. Shut off for 2 hr to take EPA samples. Mixed remaining NaCl tracer stock	108,080	49	11.1		
4/15/94 8:50	0.00	65°F, cloudy, windy, humid	System on. Equalized mix tanks	124,190	46	10.9		
4/16/94 15:00	0.40	75°F, clear, light breeze	System on. Installed new PSEKRL stock pump	137,820	45	11.0		
4/17/94 16:00	0.00	80°F, clear, light breeze	System on. Increased stock flow from 108/111 to 110/115.	157,660	44	11.0		
4/18/94 8:30	0.00	60°F, clear, light breeze	System on	173,780	44	11.0		
4/19/94 9:00	0.00	70°F, cloudy, breezy	System on	184,690	45	11.0		
4/20/94 8:50	0.00	65°F, partly cloudy, it breeze	System on	200,170	44	10.9		
4/21/94 9:10	0.20	70°F, overcast, rainy	System on	215,720	45	11.1		
4/22/94 9:00	0.60	70°F, cloudy, breezy	System on. Mixed KNO3 stock	231,800	45	11.1	150	500
4/22/94 10:30	0.00		System off (power outage=>flow imbalance?)	239,280				
4/23/94 18:00	0.00	75°F, clear, it breeze	Restarted system; readings taken at 12:10	240,500	45	11.1		
4/24/94 17:25	0.00	75°F, clear, it breeze	System on.	259,910	44	11.0		
4/25/94 9:20	0.00	75°F, it SE breeze	System on. Turned off CI feed and CI stock pump (only 25 gal left)	275,190	44	10.9		
4/26/94 9:10	0.00	Clear, humid	System on.	285,520	44	10.9		
4/27/94 8:40	0.00	75°F, very light SE wind	System on.	298,680	44	10.9		
4/28/94 8:45	0.00	70°F, humid, SE 8-10mph	System on. Rerouted pump intake lines on mixer tanks	313,980	44	10.9		
4/29/94 10:20	0.00	80°F, humid, SE 10-17mph	System on.	328,330	46	10.9		
4/30/94 17:35	0.00	70°F, cldy, overcast, NE 5-10mph	System on.	344,660	46	10.8		
5/1/94 18:15	0.90	70°F, rainy, NW wind	System on.	364,550	46	10.9		
5/2/94 9:00	0.10	70°F, rainy, NW 5-10mph	System on.	380,090	46	10.5		
5/3/94 9:00	0.00	Cloudy, showers, SE wind	System on.	388,390	46	10.5		
5/4/94 9:50	0.00	75°F, clear, NW breeze	System on.	419,630	46	10.5		
5/5/94 0:00	0.00	75°F, clear SE breeze	System on.	434,470	46	10.4		

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

Date		Background Rain Gauge (in)	Weather	Comments	Nitrate Cell				Volume Water Added to Stock Tank (gal)
					Totalizer (gallons)	Pressure (psi)	Cell Flow Rate (GPM)	Mass KNO3 Added to Stock Tank (lbs)	
5/6/94 9:30	0.00		75F, SE breeze	System on.	449,180	46	10.4		420
5/7/94 19:30	0.00		70F, clear SE 10mph	System off. NO3 stock got too low. Mixed stock	458,500			130	
5/9/94 16:40	0.10		80F, clear SW 10-15mph	System on.	471,280	46	10.5		
5/9/94 13:10	0.00		75F, clear, it SE breeze	System on. Totalizers may have trash build-up.	483,480	46	10.2		
5/10/94 9:15	0.00		70F, cloudy, SW breeze	System on.	495,550	46	10.2		
5/11/94 9:15	0.00		75F, clear, it SE breeze	System on.	509,820	46	10.2		
5/12/94 9:10	0.00		75F, cloudy, NW 8-12mph	System on.	524,080	46	10.1		
5/13/94 10:05	0.60		75F, cloudy, E 5 mph	System on. Sprinkler maintenance on Control cell.	539,490	46	10.1		
5/14/94 18:15	0.00		75F, NW 5-10mph	System on.	558,050	46	10.1		
5/15/94 16:45	0.00		80F, NE breeze	System on. Algal growth on bottom of Nitrate Stock tank.	571,370	46	10.0		
5/16/94 8:45	0.00		75F, clear	System on. Turned off for 15 min to mow grass.	580,740	46	10.1		
5/17/94 9:45	0.00		72F, it SW breeze	System on.	595,280	46	10.0		
5/18/94 8:15	0.00		65F, SW 10-15mph	System on.	608,580	46	10.0		
5/19/94 11:35	0.00		75F, SW breeze	System on. Tried switching on/off sprinklers to increase flow rate.	624,600	46	9.9		
5/20/94 9:20	0.00		70F, SW breeze	System on. Cleaned out totalizers.	637,770	46	10.1		
5/21/94 17:30	0.00		70F, it N breeze	System on.	657,960	46	11.3		
5/22/94 17:00	0.00		75F, SW 8-15mph	System on.	673,040	46	11.4		
5/23/94 11:25	0.00		80F, W 5-10mph	System on. Covered Control Mix Tank and removed algae.	685,590	46	11.4		
5/24/94 9:25	0.00		80F, SW 10-15mph	System on. Flow gauge maintenance.	700,580	46	11.3		
5/25/94 9:30	0.00		85F, W 11-17mph	System on. Mixed NO3 stock.	716,900	46	11.3	150	500
5/26/94 10:05	0.00		75F, SE 10-15mph	System on.	733,630	46	11.4		
5/27/94 9:50	1.00		75F, W 10-15mph	System on. NO3 stock flow off due to trash obstruction.	749,850	46	11.4		
5/28/94 13:20	0.00		SW 5-15mph	System on. Influent = 6.8 mg/L NO3-N. Increased NO3 stock flow rate.	768,550	46	11.4		
5/29/94 16:30	0.00		75F, SW 5-15mph	System on. Influent = 6.6-7.0 mg/L NO3-N. Increased NO3 stock flow rate.	787,090	46	11.4		
5/30/94 18:00	0.00		72F, it SW breeze	System on. Replaced North corner sprinkler in Control Cell since it wasn't rotating.	804,380	46	11.4		
5/31/94 9:55	0.45		Rain, it SE breeze	System on.	815,030	46	11.4		
6/1/94 10:25	0.00		85F, cldy	System on.	831,860	46	11.4		
6/2/94 9:30	0.20		80F, cldy, SE 0-10mph	System on.	847,650	46	11.4		
6/3/94 10:20	0.00		88F, it SE breeze	System on.	864,620	46	11.4		
6/4/94 17:30	0.00		SW 10-15mph	System on.	885,890	46	11.4		
6/5/94 18:40	0.10		75F, rainey	System on.	903,110	46	11.4		
6/6/94 13:35	2.70		75F, rain, SE 10-20mph	System on.	916,050	46	11.4		
6/7/94 9:10	0.10		Cldy, SW 5-15mph	System on.	929,510	46	11.4		
6/8/94 9:05	0.00		80F, cldy, SW 5-15mph	System on.	963,710	46	11.4		
6/9/94 10:00	0.00		85F, cldy, SE 10-15mph	System on. Partial mix of NO3 stock in prep for SH tracer study.	982,890	46	11.4	1	10
6/10/94 15:20	0.55		85F, cldy, SW 10-20mph	System on. Shut-down at 7:30 due to low stock. Restart water only at 11:00, stocks at 3:00.	980,490	47	11.1	150	500
6/11/94 8:45	0.00		80F, it N wind	System on.	992,170	47	11.3		
6/12/94 14:04	0.00		90F, cldy, mod SW wind.	System on.	1,011,960	46	11.3		
6/13/94 7:45	0.00		Cldy, calm	System on. EPA sampling.	1,023,840	48	11.4		
6/14/94 9:30	0.00		Clear, it SW breeze	System on.	1,042,100	46	11.4		
6/15/94 10:00	0.00		90F, clear, calm	System on.	1,057,750	46	11.4		
6/16/94 8:20	0.00		Clear, it NE breeze	System on.	1,072,870	46	11.4		
6/17/94 9:30	1.40		75F, cldy, calm	System on.	1,090,040	46	11.4		
6/18/94 9:30	0.90		79F, cldy, SE 5-15mph	System on.	1,106,170	46	11.4		
6/19/94 14:20	0.05		78F, cldy, it NE breeze	System on.	1,125,600	46	11.4		
6/20/94 7:30	3.00		77F, rainey, it E breeze	System off. NO3 center sprinkler had been off 8-11 AM. Surveying, sprinklers off periodically.	1,131,520				
6/21/94 7:00	0.00		75F, cldy, calm	System off. Mix tanks again out of balance.	1,146,030				
6/22/94 11:15	0.00		Cldy, S 5-15mph	System on. Disconnected CI stock pump.	1,164,800	46	11.3		

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

Date	Background Rain Gauge (in)	Weather	Comments	Nitrate Cell				Volume Water Added to Stock Tank (gal)
				Totalizer (gallons)	Pressure (psi)	Cell Flow Rate (GPM)	Mass KNO3 Added to Stock Tank (lbs)	
6/23/94 11:35	1.60	80F, rain, SE 10-20mph	System on.	1,181,220	46	11.3		
6/24/94 10:15	0.90	85F, cldy, SW 15-30mph	System on.	1,196,840	46	11.3		
6/25/94 17:25	1.40	74F, clear, lt S breeze	System off. NO3 stock tank empty. Remixed NO3 stock.	1,203,670			150	500
6/26/94 17:30	0.10	80F, cldy, S 8-15mph	System on. NO3 stock flow plugged. NO3 mix tank will have low concentrations.	1,219,070	46	11.3		
6/27/94 7:40	0.00	75F, cldy, SW 8-20mph	System on. Full EPA sampling.	1,228,600	46	11.3		
6/28/94 9:05	0.00	80F, cldy, SE 5-15mph	System on.	1,245,560	46	11.3		
6/29/94 10:05	0.00	85F, cldy, S 5-15mph	System on.	1,262,380	46	11.3		
6/30/94 9:35	0.00	85F, lt SE breeze	System on.	1,278,220	46	11.2		
7/1/94 9:30	0.00	80F, lt NW breeze	System on.	1,294,370	47	11.2		
7/2/94 11:50	0.00	80F, W 20mph	System on.	1,312,090	47	11.2		
7/3/94 11:30	5.00	TS Alberto, 60mph wind	System on.	1,328,040	47	11.2		
7/4/94 11:00	1.60	85F, rain	System on.	1,343,800	47	11.4		
7/5/94 10:40	0.10	80F, SW 5-10mph	System on.	1,359,730	47	11.2		
7/6/94 11:00	3.70	80's, rain	System on.	1,376,220	47	11.4		
7/7/94 10:00	5.60	75F, rain	System on.	1,391,630	47	11.2		
7/8/94 9:30	0.35	80F, lt rain, S 5-10mph	System on.	1,407,450	47	11.2		
7/9/94 16:40	0.00	85F, cldy	System on.	1,428,610	46	11.2		15
7/10/94 17:30	0.01	84F, lt SE breeze	System on.	1,445,340	46	11.3		
7/11/94 9:25	0.70	80F, cldy	System on.	1,455,930	46	11.2		500
7/12/94 9:10	3.30	75F, rain, SE 5-10mph	System on.	1,470,680	46	11.3	150	
7/13/94 12:45	1.50	80F, rain, lt SW breeze	System on.	1,489,230	46	11.2		
7/14/94 10:30	2.00	75F, rain, SE 10-15mph	System on.	1,503,900	46	11.2		
7/15/94 9:15	0.00	83F, clear, lt SE breeze	System on.	1,519,240	46	11.3		0
7/16/94 13:10	0.00	80F, cldy, SW 5-15mph	System on.	1,538,130	46	11.3		
7/17/94 18:20	0.60	80F, cldy, calm	System on.	1,557,520	46	11.2		
7/18/94 10:55	0.00	85F, SW 5-10mph	System on.	1,568,760	46	11.2		
7/19/94 0:00	0.00	90F, clear, lt SW breeze	System on.	1,585,420	46	11.3		
7/20/94 9:45	0.00	80F, clear, W 10mph	System on.	1,600,410	46	11.2		
7/21/94 10:35	0.85	80F, cldy	System on.	1,617,170	46	11.2		
7/22/94 9:35	0.50	90F, cldy, lt SE breeze	System on.	1,632,750	46	11.3		
7/23/94 13:55	0.00	85F, cldy, lt E breeze	System on.	1,651,860	46	11.3		
7/24/94 16:25	0.00	90F, clear, lt SW breeze	System on.	1,669,850	46	11.2		
7/25/94 9:30	0.00	90F, clear	System on.	1,681,320	46	11.3		
7/26/94 8:00	0.30	80F, cldy, lt SE breeze	System on.	1,696,820	46	11.3		
7/27/94 11:20	1.10	80F, rain, lt SE breeze	System on.	1,714,450	46	11.3		
7/28/94 10:25	0.00	72F, cldy, lt SE breeze	System on.	1,729,490	46	11.3		
7/29/94 9:45	0.00	75F, clear, lt var breeze	System on.	1,745,920	46	11.3		500
7/30/94 15:05	0.00	85F, cldy, SW 5-10mph	System off due to low NO3 stock. Mixed NO3.	1,761,630			300	
7/31/94 19:20	0.30	70F, rain, calm	System on.	1,780,490	46	11.3		
8/1/94 13:20	0.15	85F, cldy, calm	System on.	1,792,630	46	11.3		
8/2/94 8:05	0.80	80F, clear	System on.	1,805,450	46	11.3		
8/3/94 16:00	1.10	90F, clear, E 5-10mph	System on.	1,826,740	46	11.3		
8/4/94 10:45	0.00	85F, clear, E 5-10mph	System on. Replaced sprinkler heads in center and NE side of NO3 cell.	1,839,470	46	11.3		
8/5/94 9:10	0.00	85F, clear, lt SE breeze	System on. Shut down at 1705 hr to let drain for lawn maintenance.	1,854,930	46	11.5		
8/6/94 19:00	0.00	85F, clear, lt var breeze	System off. Restarted at 1922 hr.	1,860,350	46	11.5		
8/7/94 17:50	0.30	rain, var 10-20 mph	System on.	1,875,950	46	11.5		
8/8/94 8:50	1.00	75F, cldy, lt var breeze4	System on.	1,886,300	47	11.5		
8/9/94 8:55	0.00	80F, clear, calm	System on.	1,902,170	47	11.5		
8/10/94 8:50	0.00	80F, clear, lt NW breeze	System on.	1,918,820	47	11.5		

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

		Background Rain Gauge (in)		Weather		Comments		Nitrate Cell				Volume Water Added to Stock Tank (gal)			
Date										Cell Flow Rate (GPM)		Mass KNO3 Added to Stock Tank (lbs)		Volume Water Added to Stock Tank (gal)	
8/11/94 9:25		0.15		80F, rain, W 3-10mph		System on		1,935,510		47		11.5			
8/12/94 12:00		0.00		90F, cldy, SW 5-10mph		System on		1,953,700		47		11.5			
8/13/94 12:45		0.00		85F, cldy, SE 5-12mph		System on		1,970,770		47		11.5			
8/14/94 19:30		0.15		75F, rain, calm		System on		1,992,010		47		11.5			
8/15/94 12:00		0.00		85F, cldy, SE 5-25mph		System on		2,003,210		47		11.5			
8/16/94 9:05		0.00		85F, cldy, E 5-20mph		System on. Shut down at 0900 hr to let drain for lawn maintenance.		2,017,460		47		11.5		300	
8/18/94 10:00		0.10		80F, rain, SE breeze		System off. Restarted at 1000 hr.		2,018,330		47		11.4			
8/19/94 09:00		0.00		80F, clear, SE breeze		System on. Shut down at 0900 hr for interim performance evaluation.		NA		NA		NA			
8/22/94 0:00		1.40		80F, clear, SE breeze		System still off		NA		NA		NA			
8/31/94 15:40		0.00		70F, SE breeze		System off. Restarted at 1540 hr.		2,033,940		48		11.5			
9/1/94 9:00		0.00		80F, clear, E breeze		System on		2,045,580		48		11.5			
9/2/94 10:50		0.00		85F, clear, SE breeze		System on		2,063,270		48		11.5			
9/6/94 10:10		0.00		80F, clear, W breeze		System on		2,128,820		48		11.5			
9/7/94 9:00		1.80		75F, rain, SE breeze		System on		2,143,690		48		11.5			
9/8/94 9:45		0.00		80F, cldy, E 5-10mph		System on		2,160,590		48		11.5			
9/9/94 9:00		0.20		80F, clear, SE breeze		System on		2,176,700		48		11.5			
9/10/94 13:00		0.00		80F, cldy, var wind		System on		2,195,880		48		11.5			
9/11/94 14:00		0.00		80F, cldy, NW breeze		System on		2,213,150		48		11.5			
9/12/94 8:50		0.15		75F, clear, SE breeze		System on		2,226,250		48		11.5			
9/13/94 9:00		0.00		72F, clear, SE 10-20mph		System on		2,242,900		48		11.5			
9/14/94 8:30		0.00		72F, clear, E 10-20mph		System off due to low NO3 stock. Mixed NO3.		2,255,820		NA		NA		300	
9/15/94 9:00		0.15		75F, cldy, SE breeze		System on		2,271,600		48		11.5			
9/16/94 8:30		0.25		rain, ENE breeze		System on		2,287,870		48		11.5			
9/17/94 12:00		0.30		80F, cldy, SE 10-20mph		System on		2,306,760		48		11.5			
9/18/94 14:00		0.00		80F, cldy, ESE breeze		System on		2,324,700		48		11.5			
9/19/94 9:00		0.00		75F, clear, SE breeze		System on		2,337,810		48		11.5			
9/20/94 9:15		0.00		65F, cldy, SE breeze		System on		2,353,640		48		11.5			
9/21/94 9:00		0.00		75F, clear, SE 5-10mph		System on		2,369,960		48		11.5			
9/22/94 9:00		0.00		80F, clear, SE 5-10mph		System on		2,386,440		48		11.5			
9/23/94 13:50		1.10		80F, cldy, SW 5-10mph		System on		2,406,360		48		11.5			
9/24/94 12:45		0.00		80F, clear, SE 5-10mph		System on		2,422,030		48		11.5			
9/25/94 15:30		0.10		75F, cldy, SW 5-10mph		System on		2,440,480		48		11.5			
9/26/94 9:20		0.00		60F, clear, SE breeze		System on		2,452,810		48		11.5			
9/27/94 8:40		0.00		70F, clear, SE breeze		System on		2,468,750		48		11.5			
9/28/94 9:15		0.00		75F, clear, SE breeze		System on. Replaced control psi gauge.		2,485,590		48		11.5			
9/29/94 9:30		0.00		75F, clear, calm		System on. Shut down at 1615 hr to let drain for lawn maintenance.		2,502,190		48		11.4			
9/30/94 12:00		0.00		90F, clear, E 5-10mph		System off. Restart at 1335 hr.		2,506,670		48		11.5			
10/1/94 16:00		0.70		70F, rain, SE 10-30mph		System on		2,524,820		48		11.5		300	
10/2/94 18:20		6.00		rain, SE 5-30mph		System on		2,543,110		48		11.5			
10/3/94 9:30		0.10		75F, cldy, SE 5-10mph		System on		2,553,430		48		11.5			
10/4/94 10:15		0.00		72F, cldy, S 5-15mph		System on		2,570,120		48		11.5			
10/5/94 8:55		0.00		72F, clear, SE breeze		System on		2,585,750		48		11.4			
10/6/94 11:35		0.00		80F, clear, SE breeze		System on		2,603,880		48		11.5			
10/7/94 9:00		0.00		65F, clear, SE 10-20mph		System on		2,618,650		48		11.5			
10/8/94 12:10		0.00		75F, cldy, SE 10-15mph		System on		2,637,310		45		11.5			
10/9/94 18:05		0.60		70F, rain, SE breeze		System on		2,657,810		45		11.4			
10/10/94 12:45		0.80		cldy, rain		System on		2,670,510		48		11.4			
10/11/94 9:00		0.55		60F, cldy, NE 10-20mph		System on		2,684,530		48		11.4			
10/12/94 9:10		0.65		62F, cldy, NE 5-15mph		System on		2,701,000		48		11.4			

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

Date	Background Rain Gauge (in)	Weather	Comments	Nitrate Cell				Volume Water Added to Stock Tank (gal)
				Totalizer (gallons)	Pressure (psi)	Cell Flow Rate (GPM)	Mass KNO ₃ Added to Stock Tank (lbs)	
10/13/94 9:15	0.00	70F, cldy, SE 5-10mph	System on. Shut down 0930-1620 to mow.	2,717,550	48	11.4		
10/14/94 9:55	0.00	68F, cldy, N 5-15mph	System on	2,729,890	48	11.5		
10/15/94 13:00	0.00	75F, cldy, SE 5-15mph	System on	2,731,710	48	11.5		
10/16/94 13:30	0.00	75F, clear, SE 10-20mph	System on	2,765,090	48	11.5		
10/17/94 8:45	0.00	65F, cldy, E 5-15mph	System on	2,778,360	48	11.5	300	500
10/19/94 16:45	0.00	70F, clear, SE 5-10mph	System shut off yesterday to repair sprinkler seals; restarted 12:50 hr	2,791,750	48	11.6		
10/20/94 9:30	0.00	75F, clear, SE 5-10mph	System on	2,803,350	48	11.7		
10/21/94 8:35	0.00	70F, cldy, SE breeze	System on	2,819,590	48	11.6		
10/22/94 14:30	0.50	75F, cldy, NNWS-20mph	System on	2,840,260	48	11.6		
10/23/94 15:30	0.00	78F, cldy, SE 5-10mph	System on	2,857,920	48	11.6		
10/24/94 9:10	0.00	70F, clear, SE breeze	System on	2,868,810	48	11.6		
10/25/94 9:10	0.00	65F, clear, SE 0-8mph	System on	2,886,500	48	11.6		
10/26/94 9:00	0.00	60F, cldy, N 10-20mph	System on	2,903,000	48	11.6		
10/27/94 12:00	0.00	65F, clear, E 5-20mph	System on	2,921,620	48	11.6		
10/28/94 10:00	0.00	65F, cldy, SE 5-10mph	System on	2,936,820	48	11.6		
10/29/94 13:00	0.00	70F, cldy, SE 5-10mph	System on	2,955,850	48	11.6		
10/30/94 13:00	0.00	70F, cldy, SE 5-10mph	System on	2,975,470	48	11.6		
10/31/94 9:10	0.15	75F, cldy, N 5-10mph	System on	2,987,040	48	11.6		
11/1/94 8:45	0.00	65F, clear, NW 10-20mph	System on	3,002,450	48	11.6		
11/2/94 9:00	0.00	65F, clear, NW 5-15mph	System on. Shut down 10:15-1220 to mow.	3,019,150	48	11.5	300	500
11/3/94 9:00	0.00	70F, clear, NW 5-15mph	System on	3,034,200	48	11.5		
11/4/94 9:30	0.00	75F, clear, calm	System on	3,049,930	48	11.5		
11/5/94 14:00	0.00	80F, clear, SE 10-20mph	System on	3,069,540	48	11.5		
11/6/94 19:00	0.20	70F, clear, SW 10-15mph	System on	3,089,360	48	11.6		
11/7/94 7:55	0.00	60F, clear, SE breeze	System on	3,098,250	48	11.5		
11/8/94 7:00	0.00	65F, cldy, SE breeze	System on	3,114,050	48	11.5		
11/9/94 11:20	0.00	80F, clear, SW 0-5mph	System on	3,133,440	45	11.5		
11/10/94 9:20	0.00	65F, cldy, calm	System on	3,148,550	48	11.4		
11/11/94 10:00	0.00	65F, cldy, E 5-15mph	System on. Shut down at 1630 to let drain for EPA sod-removal work	3,165,390	48	11.5		
11/18/94 13:00	0.00	75F, clear, E 5-10mph	System off. Restart system at 1300 hr	3,169,440	48	11.5		
11/19/94 19:15	0.00	75F, clear, SE breeze	System on	3,189,820	48	11.5		
11/20/94 18:00	0.00	75F, cldy, SE breeze	System on	3,205,500	48	11.5		
11/21/94 10:00	0.00	75F, cldy, SW 10-20mph	System on	3,216,530	48	11.4		
11/22/94 9:30	0.00	60F, cldy, N 10-15mph	System on. Replaced center sprinkler on control cell - higher flow rate	3,232,400	48	11.4		
11/24/94 14:15	0.00	60F, cldy, SE breeze	System on	3,268,390	48	11.5		
11/25/94 17:25	0.00	60F, cldy, SE breeze	System off due to low nitrate. Mixed nitrate stock.	3,277,010	48	11.5	300	500
11/26/94 18:20	0.00	65F, cldy, SE breeze	System on	3,294,450	48	11.5		
11/27/94 17:50	0.00	65F, cldy, E 5-15mph	System on	3,310,520	48	11.5		
11/29/94 13:30	1.30	60F, rain, W 10-25mph	System off due to imbalance. Restarted 0925 hr	3,335,200	48	11.5		
11/30/94 9:30	0.40	53F, cldy, NE 5-15mph	System on. Replaced center sprinkler on nitrate cell - higher flow rate.	3,348,860	48	11.5		
12/1/94 9:30	0.00	55F, cldy, SE 5-10mph	System on	3,365,540	48	11.9		
12/2/94 11:00	0.00	60F, cldy, SE 5-10mph	System on. Replaced two side sprinklers in control cell to balance rate.	3,383,650	49	11.9		
12/3/94 16:30	0.00	65F, cldy, SW 5-15mph	System on	3,404,380	49	11.9		
12/4/94 18:35	1.90	69F, cldy, SE 5-10mph	System on	3,422,700	49	11.8		
12/5/94 10:20	0.00	63F, cldy, SW 5-10mph	System on	3,433,820	49	11.8		
12/6/94 9:25	0.00	63F, cldy, calm	System on	3,450,170	49	11.8		
12/7/94 8:15	0.00	65F, cldy, calm	System on	3,466,330	49	11.8		
12/8/94 8:35	0.00	65F, clear, N wind	System on	3,483,680	49	11.8		
12/9/94 11:25	0.00	70F, cldy, SE 5-10mph	System on	3,502,590	49	11.8		

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

						Nitrate Cell			

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

Date	Background Rain Gauge (in)	Weather	Comments	Nitrate Cell				Volume Water Added to Stock Tank (gal)
				Totalizer (gallons)	Pressure (psi)	Cell Flow Rate (GPM)	Mass KNO ₃ Added to Stock Tank (lbs)	
2/4/95 12:00	0.15	55F, clear, NE 10-40mph	System off due to low nitrate; restart at 13:50 hr	4,435,120	49	11.7	300	480
2/5/95 15:30	0.00	65F, clear, NW 10-40mph	System on	4,451,880	49	11.7		
2/6/95 9:40	0.00	39F, clear, NW 10-20mph	System on	4,464,370	49	11.7		
2/7/95 8:25	0.00	40F, clear, calm	System on	4,479,530	49	11.7		
2/8/95 9:00	0.00	35F, clear, W 10-15mph	System on	4,496,500	49	11.7		
2/9/95 9:00	0.00	30F, clear, S 5-10mph	System on	4,512,980	49	11.7		
2/10/95 11:30	0.30	68F, cldy, SW 5-10mph	System on	4,531,210	49	11.7		
2/11/95 14:00	0.80	50F, cldy, NE 10-20mph	System on	4,549,200	49	11.7		
2/12/95 15:00	0.50	55F, cldy, NE 5-20mph	System on	4,561,750	49	11.7		
2/13/95 9:30	0.10	48F, cldy, SW 5-10mph	System on	4,575,570	49	11.7		
2/14/95 8:30	0.00	50F, cldy, SW 5-10mph	System on	4,595,400	49	11.7		
2/15/95 9:00	0.00	63F, cldy, SW 5-10mph	System on	4,612,720	49	11.7		
2/16/95 9:00	0.05	66F, cldy, SE breeze	System on	4,628,780	49	11.7		
2/17/95 11:55	0.00	70F, cldy, calm	System on	4,647,430	49	11.7	300	475
2/18/95 13:00	0.10	70F, cldy, SE 5-10mph	System on	4,664,840	49	11.7		
2/19/95 13:00	0.00	65F, cldy, SE breeze	System on	4,682,180	49	11.7		
2/20/95 9:10	0.75	65F, clear, NW 10-20mph	System on	4,694,460	49	11.7		
2/21/95 8:20	0.00	60F, clear, NW 10-20mph	System on	4,709,550	49	11.7		
2/22/95 8:30	0.00	45F, clear, NW 5-10mph	System on	4,726,180	49	11.7		
2/23/95 9:30	0.00	65F, clear, NW 10-20mph	System on	4,743,250	49	11.7		
2/24/95 10:20	0.00	65F, clear, NW 10-20mph	System on	4,760,200	49	11.7		
2/25/95 11:40	0.00	65F, clear, NW 5-15mph	System on	4,777,590	49	11.7		
2/26/95 14:00	0.00	70F, clear, SW 5-10mph	System on	4,795,940	49	11.7		
2/27/95 10:15	0.00	68F, cldy, SW 10-20mph	System on	4,809,460	49	11.7		
2/28/95 8:40	0.10	68F, cldy, S 5-10mph	System on	4,824,920	49	11.7		
3/1/95 8:50	0.48	60F, cldy, NW 10-20mph	System on	4,841,470	49	11.7		
3/2/95 8:40	0.00	50F, cldy, NW 5-15mph	System on	4,857,880	49	11.7		
3/3/95 7:50	0.00	55F, cldy, N 5-15mph	System on	4,873,730	49	11.7	300	480
3/4/95 12:35	0.00	65F, clear, NW 5-15mph	System off due to low nitrate; restart at 14:40 hr	4,891,170	49	11.7		
3/5/95 18:05	0.15	65F, clear, SE breeze	System on	4,909,770	49	11.7		
3/6/95 9:00	0.00	68F, cldy, calm	System on	4,920,020	49	11.7		
3/7/95 8:50	0.00	68F, clear, SW 5-10mph	System on	4,935,570	49	11.6		
3/8/95 7:30	1.15	46F, cldy, N 10-20mph	System on	4,951,240	49	11.6		
3/9/95 9:00	0.00	50F, clear, NE 10-20mph	System on	4,968,760	49	11.6		
3/10/95 9:50	0.00	55F, clear, NW 10-15mph	System on	4,985,860	49	11.6		
3/11/95 14:30	0.00	65F, cldy, E breeze	System on	5,005,530	49	11.6		
3/12/95 12:00	0.00	68F, clear, E 10-30mph	System on	5,020,430	49	11.6		
3/13/95 9:20	0.00	65F, clear, E 10-20mph	System on	5,035,180	49	11.6		
3/14/95 8:50	0.00	65F, cldy, E 10-20mph	System on	5,051,360	49	11.6		
3/15/95 9:00	0.90	65F, cldy, E 10-20mph	System off due to yesterday's mowing. Restarted at 09:00 hr	5,065,580	49	11.6		
3/16/95 7:20	0.55	65F, cldy, ESE breeze	System on	5,083,670	49	11.6		
3/17/95 8:00	0.35	65F, cldy, N breeze	System on	5,106,000	49	11.6	300	480
3/18/95 16:30	0.00	75F, cldy, SE breeze	System off due to low nitrate; restart at 16:30 hr	5,119,720	49	11.6		
3/19/95 15:00	0.00	75F, clear, S breeze	System on	5,130,740	49	11.6		
3/20/95 9:10	0.00	75F, clear, S 5-15mph	System on	5,147,240	49	11.6		
3/21/95 9:20	0.00	65F, cldy, ESE 5-10mph	System on	5,163,340	49	11.6		
3/22/95 9:00	0.00	75F, cldy, SE 10-20mph	System on	5,164,340	49	11.6		
3/23/95 9:00	0.00	75F, clear, S 10-25mph	System still off from mowing yesterday. Restart at 9:10	5,180,600	49	11.4		
3/24/95 9:15	0.00	70F, clear, calm	System on					

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

Date	Background Rain Gauge (in)	Weather	Comments	Nitrate Cell				Volume Water Added to Stock Tank (gal)
				Totalizer (gallons)	Pressure (psi)	Cell Flow Rate (GPM)	Mass KNO ₃ Added to Stock Tank (lbs)	
3/25/95 11:00	0.00	75F, clear, lt S breeze	System on	5,198,150	49	11.4		
3/26/95 15:00	0.00	68F, cldy, ENE 10-25mph	System on	5,217,180	49	11.4		
3/27/95 11:00	0.00	75F, cldy, ESE 10-20mph	System on	5,230,750	49	11.4		
3/28/95 9:00	0.10	62F, cldy, lt N breeze	System on	5,245,750	49	11.4		
3/29/95 9:30	0.40	60F, rain, NNE 5-10mph	System on	5,262,430	49	11.4		
3/30/95 8:30	1.10	63F, cldy, N 5-10mph	System on	5,277,980	49	11.4		
3/31/95 8:45	1.30	58F, rain, lt N breeze	System on	5,294,420	49	11.4		
4/1/95 14:00	0.15	70F, clear, W 10-20mph	System on	5,314,050	49	11.4		
4/2/95 13:00	0.00	75F, clear, lt SSE breeze	System on	5,330,010	49	11.4		
4/3/95 11:40	0.00	75F, clear, SSE 5-10mph	System on	5,344,100	49	11.4		
4/4/95 8:25	0.00	64F, cldy, E 0-5mph	System off due to low nitrate and mowing; restart at 15:37 hr	5,357,890	49	11.4	300	480
4/5/95 9:20	0.00	60F, cldy, E 10-20mph	System on	5,367,990	49	11.4		
4/6/95 8:50	0.00	60F, cldy, ESE 5-10mph	System on	5,383,860	49	11.3		
4/7/95 9:15	0.00	75F, clear, S 5-10mph	System on	5,400,310	49	11.3		
4/8/95 13:30	0.00	79F, clear, ESE 5-10mph	System on	5,419,440	49	11.2		
4/9/95 14:40	0.00	80F, clear, lt ESE breeze	System on	5,436,370	49	11.2		
4/10/95 9:15	0.00	75F, clear, ESE 5-10mph	System on	5,448,920	49	11.2		
4/11/95 9:00	2.95	65F, rain, SE 10-35 mph	System on	5,464,940	49	11.2		
4/12/95 9:00	0.70	70F, cldy, ESE 5-10mph	System on	5,481,200	49	11.2		
4/13/95 10:00	0.00	75F, clear, E 5-10mph	System on	5,498,110	49	11.2		
4/14/95 9:35	0.00	75F, clear, E 0-5mph	System on	5,514,060	49	11.2		
4/15/95 13:00	0.00	80F, clear, ESE 5-10mph	System on	5,532,490	49	11.2		
4/16/95 19:00	0.00	70F, clear, lt ESE breeze	System on	5,552,540	49	11.2		
4/17/95 9:40	0.00	75F, cldy, ESE 5-10mph	System on	5,562,460	49	11.2		
4/18/95 9:10	0.00	75F, cldy, SE 5-10mph	System on	5,577,430	49	11.2		
4/19/95 11:00	0.00	80F, clear, SE 5-10mph	System on; Shut down at 19:00 hr to dry out for mowing	5,594,870	49	11.2	300	500
4/20/95 9:00	0.00	75F, cldy, SE 5-15mph	System off for mowing; restart at 09:10 hr	5,600,870	49	11.3		
4/21/95 9:30	5.50	65F, rain, E 5-15mph	System on	5,611,950	49	11.2		
4/22/95 15:40	0.10	78F, cldy, ESE 10-20mph	System on	5,632,290	49	11.2		
4/23/95 14:00	0.00	75F, cldy, SSE 5-10mph	System on	5,647,400	49	11.2		
4/24/95 8:40	1.60	58F, clear, W 5-15mph	System on	5,657,780	49	11.3		
4/25/95 8:40	0.00	70F, clear, SW 5-10mph	System on	5,674,730	49	11.2		
4/26/95 10:15	0.00	75F, clear, ESE 5-10mph	System on	5,691,030	49	11.2		
4/27/95 9:10	0.00	65F, cldy, ESE 5-10mph	System on	5,706,420	49	11.2		
4/28/95 9:00	0.00	75F, clear, calm	System on	5,722,430	49	11.2		
5/1/95 10:45	0.00	73F, cldy, calm	System on	5,771,170	49	11.2		
5/2/95 8:40	0.00	65F, cldy	System on	5,785,650	49	11.2		
5/3/95 0:00	0.00	65F, cldy	System on	5,801,390	49	11.2		
5/4/95 9:45	0.00	70F, clear	System on	5,816,270	49	11.2		
5/5/95 8:10	0.00	65F, cldy	System on	5,831,360	49	11.2	300	500
5/6/95 15:00	0.00	78F, clear	System on	5,848,020	49	11.2		
5/9/95 9:30	0.00	75F, cldy, ESE 10-20mph	System on	5,876,730	49	11.3		
5/9/95 12:40	0.00	80F, cldy, ESE 10-20mph	System on	5,895,040	49	11.2		
5/10/95 8:00	2.30	75F, rain, ENE 10-20mph	System on	5,908,460	49	11.2		
5/11/95 8:40	2.10	80F, rain, ENE 5-10mph	System on. Replaced worn sprinklers.	5,924,920	49	11.2		
5/12/95 8:30	2.00	80F, cldy, NNE 5-15mph	System on	5,941,350	49	11.9		
5/13/95 9:00	0.00	80F, clear, S 5-10mph	System on. Shut down for final sampling.					

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

Date	Control Cell				Volume Water Added to Stock Tank (gal)	Water Levels in Nitrate Cell			Water Levels in Control Cell			Water Levels Outside Treatment Cells							
	Totalizer (gallons)	Pressure (psi)	Cell Flow Rate (GPM)	Mass NaCl Added to Stock Tank (lbs)		EPA-1 (ft from TOC)	EPA-3 (ft from TOC)	Well 11 (ft from TOC)	Well R4 (ft from TOC)	EPA-2 (ft from TOC)	Well 12 (ft from TOC)	Well D (ft from TOC)	EPA-5A (ft from TOC)	EPA-5B (ft from TOC)	EPA-5C (ft from TOC)	Well R2 (ft from TOC)	Well R3 (ft from TOC)	Well C (ft from TOC)	
3/30/94 17:00						5.12	5.89	7.56	3.21	6.01	6.67	7.98	6.57	3.61	3.77	3.67	2.03	3.33	5.00
4/1/94 8:30					192														
4/1/94 2:30	3,590																		
4/1/94 19:30																			
4/2/94 8:30						5.23	5.99	7.76	3.40	6.12	6.82	8.20	6.78	3.85	4.02	3.95	2.23	3.56	5.20
4/3/94 8:45						5.29	6.04	7.82	3.44	6.18	6.92	8.25	6.83	3.88	4.06	3.99	2.29	3.60	5.26
4/4/94 16:00	8,111																		
4/4/94 17:00	9,910																		
4/5/94 14:40	9,910																		
4/5/94 19:00	12,380																		
4/6/94 7:00	15,650		11.4																
4/6/94 17:30	21,351		11.6			5.07	6.00	7.61	3.30	6.04	6.84	8.09	6.70	3.98	4.21	4.04	2.15	3.63	5.10
4/7/94 14:00	33,850					4.76	5.86	7.46	3.16	5.83	6.70	7.94	6.32	3.93	4.08	4.04	2.01	3.60	4.95
4/8/94 0:30	38,020																		
4/8/94 8:30	43,520																		
4/8/94 18:30	50,340		11.4																
4/8/94 23:00	53,280																		
4/9/94 7:30	59,080	47																	
4/9/94 13:15	62,930																		
4/9/94 20:10	67,810	48	11.4			4.63	5.72	7.29	3.10	5.67	6.52	7.77	6.31	3.94	4.04	3.98	1.93	3.55	4.81
4/10/94 15:40	80,460	47	11.5			4.56	5.71	7.30	3.05	5.65	6.54	7.75	6.33	3.88	4.03	3.95	1.88	3.52	4.79
4/11/94 9:20	92,980	42	11.3			5.12	5.96	7.76	3.36	6.01	6.81	8.09	6.67	3.90	4.06	4.00	2.16	3.61	5.10
4/12/94 13:00	100,540	47	11.3			4.43	5.65	7.17	2.90	5.52	6.46	7.63	6.22	3.50	3.71	3.65	1.64	3.29	4.64
4/13/94 8:50	114,180	47	11.3		120	4.43	5.52	7.08	2.82	5.44	6.34	7.45	6.15	3.65	3.75	3.69	1.65	3.26	4.56
4/14/94 9:20	130,650	47	11.3			4.43	5.53	7.10	2.80	5.48	6.37	7.56	6.16	3.65	3.79	3.71	1.70	3.31	4.61
4/15/94 8:50	144,700	45	11.2			4.52	5.45	7.02	2.78	5.38	6.29	7.50	6.09	3.55	3.69	3.61	1.60	3.21	4.48
4/16/94 15:00	165,080	46	11.2			4.41	5.52	7.11	2.85	5.48	6.38	7.57	6.15	3.66	3.78	3.70	1.71	3.31	4.60
4/17/94 16:00	181,830	46	11.2			4.38	5.53	7.11	2.84	5.45	6.36	7.55	6.14	3.66	3.80	3.73	1.68	3.31	4.56
4/18/94 8:30	193,180	46	11.3			4.44	5.57	7.15	2.90	5.50	6.41	7.60	6.18	3.71	3.84	3.77	1.73	3.36	4.63
4/19/94 9:00	209,330	46	11.3			4.44	5.58	7.15	2.90	5.50	6.43	7.61	6.22	3.70	3.86	3.79	1.74	3.38	4.63
4/20/94 8:50	225,550	46	11.3			4.36	5.54	7.09	2.83	5.45	6.38	7.55	6.14	3.68	3.81	3.74	1.65	3.34	4.57
4/21/94 9:10	242,130	46	11.3																
4/22/94 9:00	250,400																		
4/22/94 10:30	251,740	46	11.0			4.79	5.74	7.37	3.08	5.74	6.56	7.84	6.42	3.55	3.75	3.68	1.85	3.34	4.80
4/23/94 18:00	271,780	46	11.3																
4/24/94 17:25	287,490	46	11.1			4.52	5.72	7.23	2.98	5.60	6.51	7.70	6.29	3.75	3.90	3.83	1.81	3.41	4.72
4/25/94 9:20	298,190	46	11.2																
4/26/94 9:10	312,560	46	11.2																
4/27/94 8:40	328,300	46	11.2																
4/28/94 8:45	342,920	47	11.2																
4/29/94 10:20	359,820	47	11.1																
4/30/94 17:35	380,460	47	11.1																
5/1/94 18:15	396,430	47	10.9																
5/2/94 9:00	406,030	47	10.8			4.35	5.51	7.05	2.80	5.41	6.34	7.53	6.10	3.52	3.70	3.63	1.60	3.26	4.50
5/3/94 9:00	421,240	46	10.5																
5/4/94 9:50	437,180	47	10.8																
5/5/94 0:00	452,400	47	10.8																

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

Date	Control Cell				Volume Water Added to Stock Tank (gal)	Water Levels in Nitrate Cell				Water Levels in Control Cell				Water Levels Outside Treatment Cells			
	Totalizer (gallons)	Pressure (psi)	Cell Flow Rate (GPM)	Mass NaCl Added to Stock Tank (lbs)		EPA-1 (ft from TOC)	EPA-3 (ft from TOC)	Well R4 (ft from TOC)	EPA-2 (ft from TOC)	EPA-4 (ft from TOC)	Well R2 (ft from TOC)	Well R3 (ft from TOC)	EPA-5A (ft from TOC)	EPA-5B (ft from TOC)	EPA-5C (ft from TOC)	Well R2 (ft from TOC)	Well R3 (ft from TOC)
5/6/94 9:30	467,610	47	10.8														
5/7/94 19:30	477,420																
5/8/94 16:40	490,450	47	10.8														
5/9/94 13:10	502,980	47	10.4														
5/10/94 9:15	515,400	47	10.4														
5/11/94 9:15	529,920	47	10.4														
5/12/94 9:10	544,760	47	10.3														
5/13/94 10:05	560,470	47	10.3														
5/14/94 18:15	579,700	47	10.3														
5/15/94 16:45	593,560	47	10.3														
5/16/94 8:45	603,180	47	10.3														
5/17/94 9:45	617,740	47	10.0														
5/18/94 8:15	631,110	47	9.9														
5/19/94 11:35	647,130	47	10.0														
5/20/94 9:20	660,370	47	10.1														
5/21/94 17:30	680,960	47	11.4														
5/22/94 17:00	695,950	47	11.4														
5/23/94 11:25	708,560	47	11.4						4.95	6.02	7.64	3.34	5.98	6.90	8.10	6.69	4.07
5/24/94 9:25	723,640	47	11.4														
5/25/94 9:30	740,000	47	11.4														
5/26/94 10:05	756,730	47	11.4														
5/27/94 9:50	772,930	47	11.4														
5/28/94 13:20	791,570	47	11.4														
5/29/94 16:30	809,950	47	11.4														
5/30/94 18:00	827,300	47	11.4														
5/31/94 9:55	838,360	47	11.4						4.67	5.87	7.44	3.15	5.79	6.75	7.92	6.49	3.85
6/1/94 10:25	855,790	47	11.8														
6/2/94 9:30	872,190	47	11.8														
6/3/94 10:20	889,840	47	11.8														
6/4/94 17:30	911,960	47	11.8														
6/5/94 18:40	929,890	47	11.8														
6/6/94 13:35	943,390	47	11.8						4.30	5.49	7.03	2.75	5.38	6.43	7.59	6.14	3.26
6/7/94 9:10	957,460	47	11.8														
6/8/94 9:05	974,410	47	11.8														
6/9/94 10:00	992,360	47	11.8														
6/10/94 15:20	1,010,730	46	11.8	200	300												
6/11/94 8:45	1,022,870	47	11.7														
6/12/94 14:04	1,043,460	48	11.8														
6/13/94 7:45	1,055,840	47	11.9						4.42	5.58	7.14	2.86	5.49	6.43	7.61	6.19	3.58
6/14/94 9:30	1,073,840	47	11.9														
6/15/94 10:00	1,091,150	47	11.9														
6/16/94 8:20	1,106,950	47	11.9														
6/17/94 9:30	1,124,830	47	11.8														
6/18/94 9:30	1,141,380	47	11.8														
6/19/94 14:20	1,161,020	47	11.8														
6/20/94 7:30	1,167,550								3.38	4.35	5.90	1.81	4.22	5.21	6.29	4.79	2.19
6/21/94 7:00	1,182,600																
6/22/94 11:15	1,202,300	47	11.8														

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

Date	Control Cell				Water Levels in Nitrate Cell				Water Levels in Control Cell				Water Levels Outside Treatment Cells						
	Totalizer (gallons)	Pressure (psi)	Cell Flow Rate (GPM)	Mass NaCl Added to Stock Tank (lbs)	Volume Water Added to Stock Tank (gal)	EPA-1 (ft from TOC)	EPA-3 (ft from TOC)	Well 11 (ft from TOC)	Well R4 (ft from TOC)	EPA-2 (ft from TOC)	EPA-4 (ft from TOC)	Well 12 (ft from TOC)	Well D (ft from TOC)	EPA-5A (ft from TOC)	EPA-5B (ft from TOC)	EPA-5C (ft from TOC)	Well R2 (ft from TOC)	Well R3 (ft from TOC)	Well C (ft from TOC)
6/23/94 11:35	1,219,480	47	11.8																
6/24/94 10:15	1,235,470	47	11.8																
6/25/94 17:25	1,243,180																		
6/26/94 17:30	1,259,180	47	11.8																
6/27/94 7:40	1,269,110	47	11.8																
6/28/94 9:05	1,286,300	47	11.8																
6/29/94 10:05	1,304,270	47	11.8																
6/30/94 9:35	1,320,780	47	11.7																
7/1/94 9:30	1,337,630	47	11.8																
7/2/94 11:50	1,356,110	48	11.8																
7/3/94 11:30	1,372,760	48	11.7																
7/4/94 11:00	1,389,220	48	11.7																
7/5/94 10:40	1,405,860	48	11.7																
7/6/94 11:00	1,423,090	48	11.8																
7/7/94 10:00	1,439,220	48	11.8																
7/8/94 9:30	1,455,780	48	11.9																
7/9/94 16:40	1,477,920	47	11.8																
7/10/94 17:30	1,495,430	47	11.8																
7/11/94 9:25	1,506,540	47	11.8																
7/12/94 9:10	1,522,090	47	11.8																
7/13/94 12:45	1,541,540	47	11.8																
7/14/94 10:30	1,556,890	47	11.8																
7/15/94 9:15	1,572,920	47	11.9																
7/16/94 13:10	1,592,660	47	11.8																
7/17/94 18:20	1,613,090	47	11.8																
7/18/94 10:55	1,624,620	47	11.8																
7/19/94 0:00	1,641,870	47	11.8																
7/20/94 9:45	1,657,350	47	11.8																
7/21/94 10:35	1,674,710	47	11.8																
7/22/94 9:35	1,690,820	47	11.8																
7/23/94 13:55	1,710,600	47	11.8																
7/24/94 16:25	1,729,180	47	11.8																
7/25/94 9:30	1,741,050	47	11.8																
7/26/94 8:00	1,756,470	47	11.8																
7/27/94 11:20	1,775,380	47	11.8																
7/28/94 10:25	1,791,470	47	11.8																
7/29/94 9:45	1,807,960	47	11.8																
7/30/94 15:05	1,824,300	47	11.8																
7/31/94 19:20	1,843,790	47	11.8																
8/1/94 13:20	1,856,340	47	11.8																
8/2/94 8:05	1,869,550	47	11.8																
8/3/94 16:00	1,891,630	47	11.8																
8/4/94 10:45	1,904,710	47	11.8																
8/5/94 9:10	1,920,370	47	11.8																
8/6/94 19:00	1,925,830	47	11.8																
8/7/94 17:50	1,941,580	47	11.8																
8/8/94 8:50	1,957,200	48	11.8																
8/9/94 8:55	1,968,470	48	11.8																
8/10/94 8:50	1,985,280	48	11.8																

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

Date	Control Cell				Water Levels in Nitrate Cell				Water Levels in Control Cell				Water Levels Outside Treatment Cells				
	Totalizer (gallons)	Pressure (psi)	Cell Flow Rate (GPM)	Mass NaCl Added to Stock Tank (lbs)	Volume Water Added to Stock Tank (gal)	EPA-1 (ft from TOC)	EPA-3 (ft from TOC)	Well 11 (ft from TOC)	Well R4 (ft from TOC)	EPA-2 (ft from TOC)	EPA-4 (ft from TOC)	Well 12 (ft from TOC)	Well D (ft from TOC)	EPA-5A (ft from TOC)	EPA-5B (ft from TOC)	Well R3 (ft from TOC)	Well C (ft from TOC)
8/1/94 9:25	2,002,510	48	11.7														
8/12/94 12:00	2,021,000	48	11.8														
8/13/94 12:45	2,038,460	48	11.8														
8/14/94 19:30	2,060,120	48	11.8														
8/15/94 12:00	2,071,530	48	11.8														
8/16/94 9:05	2,086,080	48	11.8														
8/18/94 10:00	2,087,000	50	11.7														
8/19/94 09:00	NA	NA	NA														
8/22/94 0:00	NA	NA	NA														
8/31/94 15:40	2,102,870	51	11.7														
9/1/94 9:00	2,115,060	51	11.7														
9/2/94 10:50	2,132,890	51	11.7														
9/6/94 10:10	2,199,140	51	11.7														
9/7/94 9:00	2,214,190	51	11.7														
9/8/94 9:45	2,231,310	51	11.7														
9/9/94 9:00	2,247,600	51	11.7														
9/10/94 13:00	2,267,070	51	11.7														
9/11/94 14:00	2,284,530	51	11.7														
9/12/94 8:50	2,297,800	51	11.8														
9/13/94 9:00	2,314,710	51	11.8														
9/14/94 8:30	2,327,840	NA	NA														
9/15/94 9:00	2,343,810	51	11.8														
9/16/94 8:30	2,360,320	51	11.7														
9/17/94 12:00	2,379,270	51	11.7														
9/18/94 14:00	2,397,680	51	11.8														
9/19/94 9:00	2,411,130	51	11.8														
9/20/94 9:15	2,427,300	51	11.8														
9/21/94 9:00	2,444,000	51	11.8														
9/22/94 9:00	2,460,870	51	11.8														
9/23/94 13:50	2,481,280	51	11.8														
9/24/94 12:45	2,497,290	51	11.8														
9/25/94 15:30	2,516,170	51	11.8														
9/26/94 9:20	2,528,780	51	11.8														
9/27/94 8:40	2,545,060	51	11.8														
9/28/94 9:15	2,562,320	51	11.8														
9/29/94 9:30	2,579,300	45	11.7														
9/30/94 12:00	2,583,890	45	11.8														
10/1/94 16:00	2,602,270	45	11.8														
10/2/94 18:20	2,620,790	45	11.8														
10/3/94 9:30	2,631,160	45	11.8														
10/4/94 10:15	2,648,220	45	11.9														
10/5/94 8:55	2,664,280	45	11.8														
10/6/94 11:35	2,682,750	45	11.7														
10/7/94 9:00	2,697,760	45	11.8														
10/8/94 12:10	2,716,730	48	11.7														
10/9/94 18:05	2,737,560	48	11.8														
10/10/94 12:45	2,750,480	45	11.7														
10/11/94 9:00	2,764,690	45	11.7														
10/12/94 9:10	2,781,410	45	11.7														

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

Date	Control Cell				Volume Water Added to Stock Tank (gal)	Water Levels in Nitrate Cell				Water Levels in Control Cell				Water Levels Outside Treatment Cells					
	Totalizer (gallons)	Pressure (psi)	Cell Flow Rate (GPM)	Mass NaCl Added to Stock Tank (lbs)		EPA-1 (ft from TOC)	EPA-3 (ft from TOC)	Well 11 (ft from TOC)	Well R4 (ft from TOC)	EPA-2 (ft from TOC)	EPA-4 (ft from TOC)	Well 12 (ft from TOC)	Well D (ft from TOC)	EPA-5A (ft from TOC)	EPA-5B (ft from TOC)	EPA-5C (ft from TOC)	Well R2 (ft from TOC)	Well R3 (ft from TOC)	Well C (ft from TOC)
10/13/94 9:15	2,798,100	45	11.6																
10/14/94 9:55	2,810,480	45	11.6																
10/15/94 13:00	2,812,500	45	11.7																
10/16/94 13:30	2,845,570	45	11.7																
10/17/94 8:45	2,858,850	45	11.7																
10/19/94 16:45	2,872,350	45	11.7																
10/20/94 9:30	2,884,000	45	11.7																
10/21/94 8:35	2,900,200	45	11.7																
10/22/94 14:30	2,920,950	45	11.7																
10/23/94 15:30	2,938,800	45	11.7																
10/24/94 9:10	2,950,650	45	11.7																
10/25/94 9:10	2,967,420	45	11.7																
10/26/94 9:00	2,984,000	45	11.7																
10/27/94 12:00	3,002,710	45	11.7																
10/28/94 10:00	3,018,000	45	11.7																
10/29/94 13:00	3,037,090	45	11.7																
10/30/94 16:30	3,056,620	45	11.7																
10/31/94 9:10	3,068,200	45	11.6																
11/1/94 8:45	3,083,560	45	11.6																
11/2/94 9:00	3,100,190	45	11.6																
11/3/94 9:00	3,115,220	45	11.6																
11/4/94 9:30	3,130,830	45	11.5																
11/5/94 14:00	3,150,450	45	11.6																
11/6/94 19:00	3,170,310	45	11.5																
11/7/94 7:55	3,179,230	45	11.6																
11/8/94 7:00	3,195,070	45	11.6																
11/9/94 11:20	3,214,540	45	11.5																
11/10/94 9:20	3,229,710	45	11.5																
11/11/94 10:00	3,246,610	45	11.6																
11/12/94 13:00	3,250,700	45	11.6																
11/13/94 19:15	3,271,200	45	11.6																
11/20/94 18:00	3,286,910	45	11.5																
11/21/94 10:00	3,298,000	45	11.5																
11/22/94 9:30	3,313,970	45	11.5																
11/24/94 14:15	3,352,880	45	12.3																
11/25/94 17:25	3,362,240	45	12.3																
11/26/94 18:20	3,381,140	45	12.3																
11/27/94 17:50	3,398,540	45	12.3																
11/29/94 13:30	3,425,330	45	12.3																
11/30/94 9:30	3,440,120	45	12.3																
12/1/94 9:30	3,457,550	45	12.3																
12/2/94 11:00	3,476,520	45	11.8																
12/3/94 16:30	3,497,030	45	11.8																
12/4/94 18:35	3,515,110	45	11.7																
12/5/94 10:20	3,526,060	45	11.7																
12/6/94 9:25	3,542,150	45	11.7																
12/7/94 8:15	3,558,080	45	11.7																
12/8/94 8:35	3,575,210	48	11.7																
12/9/94 11:25	3,593,870	45	11.8																

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

Date	Control Cell				Volume Water Added to Stock Tank (gal)	Water Levels in Nitrate Cell				Water Levels in Control Cell				Water Levels Outside Treatment Cells					
	Totalizer (gallons)	Pressure (psi)	Cell Flow Rate (GPM)	Mass NaCl Added to Stock Tank (lbs)		EPA-1 (ft from TOC)	EPA-3 (ft from TOC)	Well 11 (ft from TOC)	Well R4 (ft from TOC)	EPA-2 (ft from TOC)	EPA-4 (ft from TOC)	Well 12 (ft from TOC)	Well D (ft from TOC)	EPA-5A (ft from TOC)	EPA-5B (ft from TOC)	EPA-5C (ft from TOC)	Well R2 (ft from TOC)	Well R3 (ft from TOC)	Well C (ft from TOC)
12/10/94 12:30	3,609,430	45	11.8																
12/11/94 17:35	3,629,520	45	11.8																
12/12/94 8:45	3,640,060	45	11.7																
12/13/94 8:15	3,655,240	45	11.8																
12/14/94 8:10	3,671,940	45	11.7																
12/15/94 8:10	3,688,510	45	11.7																
12/16/94 8:40	3,705,510	45	11.7																
12/17/94 16:20	3,727,500	45	11.7																
12/18/94 12:30	3,741,880	45	11.7																
12/20/94 9:15	3,772,800	45	11.7																
12/21/94 10:30	3,790,240	45	11.7																
12/29/94 9:30	3,923,110	45	11.7																
12/30/94 8:40	3,938,760	45	11.7																
12/31/94 16:00	3,959,810	45	11.6																
1/1/95 17:00	3,976,820	45	11.6																
1/2/95 16:10	3,992,920	45	11.6																
1/3/95 8:25	4,004,250	45	11.7																
1/4/95 8:45	4,021,140	45	11.6																
1/5/95 17:30	4,040,130	45	11.6																
1/6/95 8:50	4,050,950	45	11.6																
1/7/95 17:20	4,073,510	45	11.6																
1/8/94 16:20	4,089,570	45	11.6																
1/9/94 9:00	4,101,210	45	11.6																
1/10/95 9:10	4,117,370	45	11.7																
1/11/95 8:30	4,133,620	45	11.7																
1/12/95 8:35	4,150,430	45	11.7																
1/13/95 8:45	4,167,200	45	11.7																
1/14/95 18:00	4,190,340	45	11.7																
1/15/95 17:00	4,206,410	45	11.7																
1/16/95 8:20	4,217,130	45	11.7																
1/17/95 8:30	4,239,080	45	11.7																
1/18/95 7:35	4,250,120	45	11.7																
1/19/95 7:50	4,266,960	45	11.7																
1/20/95 7:45	4,283,430	45	11.7																
1/21/95 12:40	4,296,380	45	11.7																
1/22/95 18:00	4,317,650	45	11.7																
1/23/95 9:00	4,327,260	45	11.7																
1/24/95 12:25	4,346,370	45	11.7																
1/25/95 8:55	4,360,090	45	11.7																
1/26/95 10:15	4,377,430	45	11.7																
1/27/95 10:15	4,394,210	45	11.7																
1/28/95 13:00	4,412,720	45	11.7																
1/29/95 17:00	4,432,190	45	11.7																
1/30/95 10:00	4,444,010	45	11.7																
1/31/95 8:45	4,459,880	45	11.7																
2/1/95 8:50	4,476,630	45	11.7																
2/29/95 8:10	4,492,810	45	11.7																
2/3/95 11:00	4,511,410	45	11.7																

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

Date	Control Cell				Volume Water Added to Stock Tank (gal)	Water Levels in Nitrate Cell				Water Levels in Control Cell				Water Levels Outside Treatment Cells					
	Totalizer (gallons)	Pressure (psi)	Cell Flow Rate (GPM)	Mass NaCl Added to Stock Tank (lbs)		EPA-1 (ft from TOC)	EPA-3 (ft from TOC)	Well 11 (ft from TOC)	Well R4 (ft from TOC)	EPA-2 (ft from TOC)	EPA-4 (ft from TOC)	Well 12 (ft from TOC)	Well D (ft from TOC)	EPA-5A (ft from TOC)	EPA-5B (ft from TOC)	EPA-5C (ft from TOC)	Well R2 (ft from TOC)	Well R3 (ft from TOC)	Well C (ft from TOC)
2/4/95 12:00	4,520,800	45	11.7																
2/5/95 15:30	4,537,600	45	11.7																
2/6/95 9:40	4,550,140	45	11.7		4.22	5.44	6.96	2.83	5.36	6.26	7.48	6.05	3.71	3.75	3.88	1.62	3.41	4.47	
2/7/95 8:25	4,565,390	45	11.7																
2/8/95 9:00	4,582,500	45	11.7																
2/9/95 9:00	4,599,150	45	11.7																
2/10/95 11:30	4,617,520	45	11.7																
2/11/95 14:00	4,635,870	45	11.7																
2/12/95 15:00	4,653,420	45	11.7		3.83	5.10	6.58	2.38	4.95	5.94	7.10	5.67	3.28	3.55	3.48	1.18	3.06	4.03	
2/13/95 9:30	4,666,400	45	11.7																
2/14/95 8:30	4,682,420	45	11.7																
2/15/95 9:00	4,699,440	45	11.7																
2/16/95 9:00	4,716,150	45	11.7																
2/17/95 11:55	4,734,900	45	11.7																
2/18/95 13:00	4,752,480	45	11.7																
2/19/95 13:00	4,769,830	45	11.7		3.89	5.16	6.69	2.42	5.01	5.98	7.15	5.71	3.28	3.58	3.50	1.25	3.07	4.12	
2/20/95 9:10	4,782,300	45	11.7																
2/21/95 8:20	4,797,600	45	11.7																
2/22/95 8:30	4,814,420	45	11.7																
2/23/95 9:30	4,831,650	45	11.7																
2/24/95 10:20	4,848,810	45	11.7																
2/25/95 11:40	4,866,400	45	11.7																
2/26/95 14:00	4,884,750	45	11.7																
2/27/95 10:15	4,898,700	45	11.7		4.31	5.53	7.05	2.84	5.36	6.35	7.52	6.08	3.79	4.03	3.96	1.67	3.54	4.53	
2/28/95 8:40	4,914,310	45	11.7																
3/1/95 8:50	4,931,000	45	11.7																
3/2/95 8:40	4,947,580	45	11.7																
3/3/95 7:50	4,963,960	45	11.7																
3/4/95 12:35	4,981,140	45	11.7																
3/5/95 18:05	4,999,830	45	11.7																
3/6/95 9:00	5,016,130	45	11.7		4.32	5.65	7.17	2.96	5.49	6.42	7.63	6.19	3.90	4.14	4.07	1.79	3.66	4.63	
3/7/95 8:50	5,025,760	45	11.6																
3/8/95 7:30	5,041,530	45	11.6																
3/9/95 9:00	5,059,140	45	11.6																
3/10/95 9:50	5,076,280	45	11.6																
3/11/95 14:30	5,096,050	45	11.6																
3/12/95 12:00	5,111,020	45	11.6		4.30	5.57	7.11	2.90	5.43	6.39	7.49	6.15	3.80	4.05	3.95	1.74	3.55	4.60	
3/13/95 9:20	5,125,750	45	11.6																
3/14/95 8:50	5,141,950	45	11.6																
3/15/95 9:00	5,157,180	45	11.6																
3/16/95 7:20	5,174,630	45	11.6																
3/17/95 8:00	5,191,150	45	11.6																
3/18/95 16:30	5,210,880	45	11.6																
3/19/95 15:00	5,228,730	45	11.6																
3/20/95 9:10	5,246,020	45	11.6																
3/21/95 9:20	5,263,300	45	11.6		4.28	5.45	7.02	2.71	5.32	6.26	7.43	6.00	3.55	3.79	3.70	1.58	3.29	4.45	
3/22/95 9:00	5,280,600	45	11.6																
3/23/95 9:00	5,297,900	45	11.6																
3/24/95 9:15	5,315,200	45	11.5																

APPENDIX B (cont.) OPERATIONS AND MAINTENANCE LOG FOR PILOT DEMONSTRATION PROJECT

Date	Control Cell				Volume Water Added to Stock Tank (gal)	Water Levels in Nitrate Cell				Water Levels in Control Cell				Water Levels Outside Treatment Cells					
	Totalizer (gallons)	Pressure (psi)	Cell Flow Rate (GPM)	Mass NaCl Added to Stock Tank (lbs)		EPA-1 (ft from TOC)	EPA-3 (ft from TOC)	Well 11 (ft from TOC)	Well R4 (ft from TOC)	EPA-2 (ft from TOC)	EPA-4 (ft from TOC)	Well 12 (ft from TOC)	Well D (ft from TOC)	EPA-5A (ft from TOC)	EPA-5B (ft from TOC)	EPA-5C (ft from TOC)	Well R2 (ft from TOC)	Well R3 (ft from TOC)	Well C (ft from TOC)
3/25/95 11:00	5,290,430	45	11.6																
3/26/95 15:00	5,309,820	45	11.6			4.28	5.58	7.13	2.85	5.46	6.40	7.60	6.17	3.66	3.90	3.82	1.71	3.42	4.60
3/27/95 11:00	5,323,630	45	11.6																
3/28/95 9:00	5,338,930	45	11.6																
3/29/95 9:30	5,355,970	45	11.6																
3/30/95 8:30	5,371,910	45	11.6																
3/31/95 8:45	5,388,820	45	11.6																
4/1/95 14:00	5,409,050	45	11.6																
4/2/95 13:00	5,425,390	45	11.6																
4/3/95 11:40	5,440,020	45	11.6			3.78	5.05	6.60	2.34	4.91	5.85	7.04	5.60	3.15	3.42	3.34	1.27	2.91	4.10
4/4/95 8:25	5,454,120	45	11.6																
4/5/95 9:20	5,464,440	45	11.6																
4/6/95 8:50	5,480,640	45	11.5																
4/7/95 9:15	5,497,210	45	11.2																
4/8/95 13:30	5,516,250	45	11.3																
4/9/95 14:40	5,533,120	45	11.3																
4/10/95 9:15	5,545,610	45	11.3			4.07	5.34	6.88	2.63	5.21	6.16	7.35	5.95	3.43	3.68	3.60	1.48	3.14	4.34
4/11/95 9:00	5,561,460	45	11.3																
4/12/95 9:00	5,577,510	45	11.3																
4/13/95 10:00	5,594,220	45	11.3																
4/14/95 9:35	5,610,050	45	11.3																
4/15/95 13:00	5,628,470	45	11.3																
4/16/95 19:00	5,648,650	45	11.3																
4/17/95 9:40	5,668,530	45	11.2																
4/18/95 9:10	5,673,240	45	11.2			3.70	4.83	6.51	2.31	4.84	5.80	6.99	5.56	3.14	3.40	3.34	1.15	2.86	4.01
4/19/95 11:00	5,690,350	45	11.2																
4/20/95 9:00	5,696,310	45	11.2																
4/21/95 9:30	5,707,380	45	11.3																
4/22/95 15:40	5,727,700	45	11.3																
4/23/95 14:00	5,742,810	45	11.2			2.86	3.67	5.45	1.29	3.75	4.58	5.83	4.42	2.11	2.34	2.29	0.31	1.80	3.02
4/24/95 8:40	5,753,170	45	11.2																
4/25/95 8:40	5,770,070	45	11.2																
4/26/95 10:15	5,786,340	45	11.2																
4/27/95 9:10	5,801,690	45	11.2																
4/28/95 9:00	5,817,710	45	11.2																
5/1/95 10:45	5,866,640	45	11.2																
5/2/95 8:40	5,881,210	45	11.2			3.30	4.32	6.03	1.82	4.40	5.28	6.49	5.49	2.68	2.93	2.88	0.87	2.43	3.59
5/3/95 0:00	5,896,960	45	11.2			3.51	4.61	6.33	2.19	4.68	5.58	6.80	5.38	3.06	3.30	3.23	1.04	2.74	3.84
5/4/95 9:45	5,911,810	45	11.2																
5/5/95 8:10	5,926,870	45	11.2																
5/6/95 15:00	5,943,530	45	11.2																
5/8/95 9:30	5,972,200	45	11.3																
5/9/95 12:40	5,990,460	45	11.2																
5/10/95 8:00	6,003,700	45	11.2																
5/11/95 8:40	6,020,160	45	11.3																
5/12/95 8:30	6,036,010	45	11.7			2.59	3.05	5.03	1.02	3.37	4.18	5.42	3.99	1.86	2.09	2.00	0.15	1.42	2.75
5/13/95 9:00																			

APPENDIX C WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	SO ₂ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PAYL (ug/L)	MAXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PCSU (ug/L)	TMB (ug/L)	BTEX/TMB (ug/L)
EPA1	3/30/94	5.12	5.70	0.2	3.6	1.9	1.4	<0.05	<0.05	1.93	1.00	2.4	NA	26.5	7.6	55.0	180.0	115.0	8.3	70.1	250.0	60.7	773
EPA1	4/7/94	5.07	5.94	0.1	3.9	2.9	11.8	1.68	<0.05	0.94	0.53	14.6	NA	<1.0	4.3	14.7	41.6	59.8	3.5	51.1	111.0	96.9	343
EPA1	4/11/94	4.56	5.22	2.4	0.5	46.1	14.8	11.70	<0.05	2.06	0.08	23.7	NA	<1.0	1.0	1.1	2.9	4.1	1.0	4.4	10.0	4.5	29
EPA1	4/14/94	4.36	4.98	3.1	<0.1	40.9	10.0	9.75	<0.05	0.83	0.15	13.6	NA	<1.0	1.9	<1.0	1.7	3.1	1.9	<1.0	1.9	1.0	12
EPA1	4/18/94	4.38	5.40	1.4	<0.1	50.4	8.6	9.15	<0.05	0.50	0.15	11.3	NA	<1.0	2.3	1.0	1.9	3.1	1.8	<1.0	2.4	1.0	14
EPA1	4/21/94	4.36	5.44	1.7	<0.1	58.0	10.2	7.56	<0.05	0.12	0.17	11.2	NA	<1.0	<1.0	1.0	2.0	2.9	1.8	<1.0	1.7	<1.0	9
EPA1	4/25/94	4.52	5.58	1.2	0.1	25.3	9.6	7.84	0.06	0.17	0.21	10.5	NA	<1.0	<1.0	<1.0	2.2	<1.0	1.1	1.6	6.5	3.3	15
EPA1	5/2/94	4.35	5.65	1.7	<0.1	10.6	8.9	7.90	<0.05	<0.05	0.25	9.3	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	<1.0	2
EPA1	5/16/94	4.88	6.02	0.1	0.6	4.8	9.9	5.27	0.39	0.15	0.41	10.3	NA	<1.0	3.5	1.4	5.0	5.5	1.0	4.0	20.5	10.8	52
EPA1	5/31/94	4.67	6.12	0.8	0.0	2.1	10.0	6.50	0.18	0.50	0.45	11.2	NA	<1.0	<1.0	7.0	17.1	24.4	<1.0	2.9	26.2	14.3	92
EPA1	6/13/94	4.42	6.13	0.2	<0.1	150.0	13.4	21.50	0.10	<0.05	0.25	11.2	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	6/27/94	3.46	6.21	0.1	<0.1	9.7	9.0	1.64	<0.05	0.27	0.33	NA	NA	<1.0	<1.0	<1.0	1.3	<1.0	<1.0	<1.0	4.3	2.9	5
EPA1	7/11/94	2.66	6.60	<0.1	2.3	2.6	8.9	0.15	0.07	0.34	0.53	8.1	NA	<1.0	<1.0	<1.0	2.6	1.3	<1.0	<1.0	1.1	<1.0	5
EPA1	7/25/94	3.15	6.33	<0.1	2.0	1.3	10.9	1.84	<0.05	0.91	0.76	8.9	NA	<1.0	<1.0	<1.0	1.7	1.9	1.9	<1.0	5.9	4.6	16
EPA1	8/8/94	2.63	6.40	<0.1	2.9	1.5	8.6	0.91	<0.05	0.99	0.96	7.1	NA	<1.0	<1.0	<1.0	1.8	1.4	<1.0	<1.0	1.9	1.2	6
EPA1	8/23/94	4.34	6.07	<0.1	4.1	1.6	11.6	0.79	<0.05	1.47	0.99	5.6	NA	<1.0	1.0	18.0	39.9	46.7	60.5	6.2	98.5	57.6	328
EPA1	9/6/94	3.97	6.32	0.4	<0.1	<0.5	10.0	11.50	<0.05	<0.05	0.48	11.7	NA	<1.0	<1.0	1.0	1.0	1.2	1.0	<1.0	1.0	1.2	6
EPA1	9/19/94	3.75	6.30	0.2	<0.1	<0.5	9.2	13.40	<0.05	<0.05	0.40	8.7	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	4
EPA1	10/3/94	2.70	6.51	0.1	<0.1	1.9	5.5	8.81	<0.05	<0.05	0.53	5.8	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	10/17/94	3.35	6.00	0.1	<0.1	<0.5	9.0	11.20	<0.05	<0.05	0.39	9.8	NA	<1.0	1.0	1.0	1.3	1.3	1.1	<1.0	<1.0	<1.0	6
EPA1	10/31/94	3.82	6.60	0.8	<0.1	<0.5	8.8	16.60	<0.05	<0.05	0.36	9.6	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	11/1/94	4.10	6.68	0.1	<0.1	1.7	9.3	6.29	<0.05	<0.05	0.37	10.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	11/30/94	4.34	6.78	2.9	<0.1	<0.5	7.1	17.10	0.61	<0.05	0.42	10.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	12/12/94	3.89	6.84	3.3	0.3	<0.5	8.8	19.90	0.11	<0.05	0.33	10.2	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	12/29/94	3.91	6.85	6.3	<0.1	<0.5	9.2	20.10	<0.05	0.08	0.36	10.6	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	1/9/95	4.19	6.91	6.7	<0.1	<0.5	8.0	18.30	0.08	0.21	0.32	10.4	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	1/24/95	3.44	7.40	NA	<0.1	<0.5	6.0	10.70	<0.05	<0.05	0.41	7.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	2/6/95	4.22	7.10	NA	<0.1	<0.5	9.3	20.50	0.08	<0.05	0.37	11.0	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	2/21/95	3.89	7.05	5.0	<0.1	<0.5	8.1	34.40	0.09	<0.05	0.40	10.5	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	3/6/95	4.32	7.01	4.7	<0.1	<0.5	8.1	15.90	0.09	<0.05	<0.05	9.3	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	3/22/95	4.28	6.80	3.7	<0.1	<0.5	7.5	15.00	0.07	<0.05	0.35	10.1	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	4/3/95	3.78	6.90	4.1	<0.1	<0.5	8.6	20.40	<0.05	0.29	0.38	11.6	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	4/17/95	3.70	6.82	1.1	<0.1	1.3	9.5	19.50	<0.05	<0.05	0.38	10.3	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	4/28/95	3.30	6.84	0.1	<0.1	<0.5	10.5	13.60	<0.05	0.11	0.41	10.4	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA1	5/12/95	2.59	6.69	0.2	<0.1	<0.5	8.1	11.50	0.16	<0.05	0.41	8.0	<0.5	<1.0	2.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3
EPA1	4/20/96	4.28	6.69	0.2	<0.1	<0.5	4.9	0.50	0.50	1.46	0.67	10.5	<1.0	5.4	<1.0	9.7	4.5	3.0	<1.0	7.7	103.0	37.2	171
EPA2	3/30/94	6.01	5.68	0.2	2.3	2.1	3.5	<0.05	<0.05	0.67	<0.05	3.6	NA	11.4	633.0	244.0	569.0	1270.0	601.0	170.0	528.0	190.0	4216
EPA2	4/7/94	6.04	6.27	0.4	2.0	2.2	4.8	0.35	<0.05	0.84	<0.05	3.4	NA	6.4	28.4	107.0	302.0	601.0	95.5	148.0	359.0	172.0	1819
EPA2	4/11/94	5.65	5.11	0.2	2.6	<0.5	55.0	1.55	0.07	0.52	<0.05	12.4	NA	<1.0	13.8	33.9	72.2	148.0	48.6	46.1	106.0	58.0	527
EPA2	4/14/94	5.44	5.25	0.1	1.5	<0.5	70.8	1.24	<0.05	0.42	<0.05	14.4	NA	1.1	10.9	44.1	110.0	238.0	37.8	64.0	150.0	85.4	741
EPA2	4/18/94	5.45	6.01	0.1	0.5	<0.5	79.6	1.21	<0.05	0.11	<0.05	12.9	NA	<1.0	4.0	4.4	10.4	21.2	7.4	18.3	28.9	15.3	111
EPA2	4/21/94	5.45	5.92	0.1	1.6	<0.5	87.6	0.43	<0.05	0.24	<0.05	0.7	NA	<1.0	4.6	8.3	16.5	35.4	16.2	20.2	33.8	18.4	153
EPA2	4/25/94	5.60	5.97	0.1	1.5	<0.5	85.7	0.21	<0.05	0.23	<0.05	11.6	NA	<1.0	4.1	8.4	16.9	35.3	18.1	29.5	48.3	27.1	188
EPA2	5/2/94	5.41	6.14	0.1	0.4	<0.5	30.6	0.14	<0.05	0.05	<0.05	12.7	NA	<1.0	2.3	4.4	8.8	19.3	10.3	15.5	20.9	12.7	94
EPA2	5/16/94	5.90	6.24	0.4	0.7	<0.5	14.1	0.09	<0.05	<0.05	<0.05	12.7	NA	<1.0	2.0	8.6	18.0	34.6	32.1	90.3	126.0	94.2	406
EPA2	5/31/94	5.79	6.48	<0.1	0.2	0.6	10.0	0.25	0.09	<0.05	<0.05	10.7	NA	<1.0	<1.0	1.0	2.3	4.3	4.5	37.0	54.1	55.5	159
EPA2	6/13/94	5.49	6.64	0.1	<0.1	1.1	8.1	0.65	<0.05	<0.05	<0.05	8.5	NA	<1.0	<1.0	2.9	5.6	12.0	8.9	26.9	30.8	22.7	110
EPA2	6/27/94	4.44	6.07	0.1	1.3	<0.5	5.4	0.54	<0.05	0.73	<0.05	9.3	NA	<1.0	<1.0	<1.0	1.5	1.3	1.6	77.8	46.3	34.0	152
EPA2	7/11/94	3.70	6.25	<0.1	0.5	<0.5	19.1	0.48	0.07	0.36	<0.05	2.3	NA	<1.0	<1.0	6.4	19.1	23.1	17.5	37.4	47.8	36.0	185
EPA2	7/25/94	4.04	6.02	<0.1	1.7	1.6	4.5	<0.05	<0.05	0.14	<0.05	9.3	NA	<1.0	<1.0	1.7	4.5	6.4	6.4	55.5	44.3	33.8	153
EPA2	8/8/94	3.46	5.99	<0.1	0.9	1.5	8.4	0.08	<0.05	0.33	<0.05	4.6	NA	<1.0	1.3	2.6	6.6	9.3	8.3	86.6	54.7	43.9	213

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S ₂ O ₃ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEX/TMB (ug/L)
EPA2	8/23/94	5.19	6.00	<0.1	2.0	1.1	9.9	<0.05	<0.05	0.49	<0.05	3.4	NA	<1.0	1.0	1.3	4.2	5.3	5.7	116.0	83.8	70.6	288
EPA2	9/6/94	5.06	6.09	<0.1	1.7	1.4	12.1	0.78	0.07	0.87	<0.05	10.1	NA	<1.0	1.0	16.7	44.7	87.2	181.0	86.6	101.0	99.5	618
EPA2	9/19/94	4.88	6.37	0.1	0.8	0.5	10.4	0.26	<0.05	0.66	<0.05	8.8	NA	<1.0	<1.0	<1.0	2.0	3.5	2.5	96.5	71.9	55.9	233
EPA2	10/3/94	3.51	6.38	1.0	0.5	2.0	9.2	0.49	<0.05	<0.05	<0.05	8.6	NA	<1.0	<1.0	<1.0	1.0	1.1	1.0	82.8	54.2	38.7	179
EPA2	10/17/94	4.48	6.54	0.1	0.1	<0.5	9.4	0.36	<0.05	0.07	<0.05	9.2	NA	<1.0	<1.0	<1.0	1.0	1.0	1.0	42.7	31.6	26.0	103
EPA2	10/31/94	4.90	6.56	<0.1	1.0	<0.5	10.1	0.73	0.09	0.06	<0.05	8.5	NA	<1.0	<1.0	<1.0	2.7	1.3	1.1	166.0	144.0	122.0	437
EPA2	11/11/94	5.19	6.68	1.4	<0.1	1.8	9.1	0.42	<0.05	<0.05	<0.05	9.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	10.8	7.7	6.4	25
EPA2	11/30/94	5.09	7.00	1.5	<0.1	<0.5	8.0	0.39	<0.05	<0.05	<0.05	8.9	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.6	1.0	1.0	4
EPA2	12/12/94	5.39	7.00	1.6	0.1	<0.5	9.1	0.37	<0.05	<0.05	<0.05	9.7	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA2	12/29/94	5.18	7.10	2.9	<0.1	<0.5	9.1	0.22	<0.05	<0.05	<0.05	9.0	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	4.4	1.8	2.6	9
EPA2	1/9/95	5.44	7.08	2.6	<0.1	<0.5	8.6	0.17	<0.05	<0.05	<0.05	9.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA2	1/24/95	4.55	7.15	3.2	<0.1	<0.5	7.5	0.34	<0.05	<0.05	<0.05	9.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA2	2/6/95	5.36	7.14	NA	<0.1	<0.5	8.6	0.23	<0.05	<0.05	<0.05	10.0	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	15.6	11.6	14.1	41
EPA2	2/21/95	5.01	7.12	0.3	<0.1	<0.5	8.0	0.31	<0.05	<0.05	<0.05	8.9	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.3	1.0	1.5	6
EPA2	3/6/95	5.49	7.12	1.5	<0.1	<0.5	9.0	0.16	<0.05	<0.05	<0.05	8.8	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	26.0	6.0	9.4	41
EPA2	3/22/95	5.32	6.98	1.0	<0.1	1.0	8.0	0.32	<0.05	<0.05	<0.05	7.5	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA2	4/3/95	4.91	7.01	1.5	<0.1	<0.5	8.4	0.36	<0.05	<0.05	<0.05	8.1	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA2	4/17/95	4.84	7.01	0.9	<0.1	<0.5	8.7	0.29	<0.05	<0.05	<0.05	8.7	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA2	4/28/95	4.40	7.02	0.8	<0.1	<0.5	8.6	0.44	<0.05	<0.05	<0.05	8.8	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.9	<1.0	<1.0	4
EPA2	5/12/95	3.37	6.87	0.1	<0.1	<0.5	9.6	0.16	<0.05	0.08	<0.05	3.9	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	47.5	6.9	5.4	60
EPA2	4/20/96	5.15	6.35	<0.1	<0.1	<0.5	12.8	0.50	0.50	0.24	<0.05	13.0	<0.5	<1.0	<1.0	19.0	51.0	73.4	<1.0	132.0	176.0	139.0	590
EPA3	3/30/94	5.89	5.42	0.1	3.5	<0.5	1.3	<0.05	<0.05	1.06	<0.05	1.7	NA	10.2	655.0	527.0	737.0	1770.0	577.0	122.0	516.0	182.0	5096
EPA3	4/7/94	6.00	5.93	<0.1	2.5	3.5	2.5	<0.05	<0.05	0.79	<0.05	1.4	NA	9.0	816.0	521.0	682.0	1630.0	814.0	152.0	479.0	189.0	5292
EPA3	4/11/94	5.71	5.43	<0.1	3.0	2.8	2.2	0.12	<0.05	0.53	0.07	0.7	NA	16.8	1200.0	543.0	702.0	1760.0	1170.0	163.0	503.0	240.0	6298
EPA3	4/14/94	5.52	5.06	0.1	2.5	9.4	4.6	0.08	<0.05	0.31	<0.05	1.3	NA	15.7	951.0	459.0	596.0	1380.0	1190.0	156.0	416.0	236.0	5402
EPA3	4/18/94	5.53	5.43	0.1	2.5	10.4	7.4	0.15	<0.05	0.33	<0.05	6.2	NA	15.2	964.0	457.0	586.0	1410.0	1100.0	157.0	401.0	229.0	5319
EPA3	4/21/94	5.54	5.44	<0.1	2.8	16.7	9.6	0.07	<0.05	0.45	<0.05	11.2	NA	23.7	1190.0	533.0	647.0	1500.0	1170.0	167.0	432.0	243.0	5906
EPA3	4/25/94	5.72	5.32	0.2	2.5	23.9	9.9	<0.05	<0.05	0.56	<0.05	13.7	NA	24.4	1260.0	561.0	698.0	1620.0	1280.0	168.0	453.0	249.0	6313
EPA3	5/2/94	5.51	5.33	<0.1	2.7	20.2	8.1	<0.05	<0.05	0.89	<0.05	5.7	NA	38.5	1590.0	602.0	753.0	1770.0	1290.0	157.0	443.0	237.0	6881
EPA3	5/16/94	5.94	5.63	<0.1	2.5	23.0	9.1	<0.05	<0.05	1.28	<0.05	2.9	NA	48.1	1370.0	586.0	704.0	1700.0	1280.0	154.0	426.0	232.0	6500
EPA3	5/31/94	5.87	5.81	0.1	1.5	10.6	6.9	0.12	<0.05	2.42	<0.05	<0.5	NA	208.0	1390.0	687.0	789.0	1980.0	980.0	170.0	464.0	241.0	6910
EPA3	6/13/94	5.58	5.87	0.2	2.2	14.0	8.5	<0.05	<0.05	2.62	<0.05	0.6	NA	128.0	931.0	535.0	602.0	1510.0	1080.0	158.0	420.0	226.0	5590
EPA3	6/27/94	4.46	6.08	<0.1	0.5	7.0	4.5	<0.05	<0.05	1.40	<0.05	NA	NA	5.3	263.0	179.0	230.0	580.0	469.0	85.1	202.0	112.0	2125
EPA3	7/11/94	3.51	6.52	0.2	3.4	1.8	3.2	0.06	<0.05	<0.05	<0.05	3.6	NA	1.1	49.3	13.8	15.6	33.2	33.8	4.9	9.4	6.0	167
EPA3	7/25/94	3.94	6.02	<0.1	4.9	7.1	6.3	<0.05	<0.05	0.82	<0.05	0.7	NA	19.4	1130.0	318.0	350.0	893.0	420.0	27.7	88.0	57.0	3303
EPA3	8/8/94	3.14	6.08	0.6	3.4	2.4	3.0	<0.05	<0.05	0.64	<0.05	3.1	NA	2.1	224.0	56.4	61.3	152.0	84.5	8.4	18.8	15.9	623
EPA3	8/23/94	5.02	5.68	<0.1	3.9	5.9	8.9	<0.05	<0.05	1.86	<0.05	<0.5	NA	19.4	2100.0	777.0	855.0	2120.0	899.0	93.7	306.0	166.0	7386
EPA3	9/6/94	5.10	5.83	<0.1	4.2	5.6	7.2	<0.05	<0.05	2.10	<0.05	<0.5	NA	7.3	938.0	480.0	564.0	1320.0	576.0	96.0	246.0	141.0	4368
EPA3	9/19/94	4.92	5.83	<0.1	5.1	4.5	9.6	0.06	<0.05	1.54	<0.05	<0.5	NA	3.4	299.0	138.0	176.0	418.0	323.0	53.7	135.0	101.0	1647
EPA3	10/3/94	3.38	6.32	0.7	1.4	2.1	3.2	1.16	<0.05	0.44	<0.05	4.8	NA	<1.0	4.5	5.4	7.5	16.3	12.7	5.7	11.0	6.7	70
EPA3	10/17/94	4.30	6.10	0.1	2.5	1.6	7.5	0.21	<0.05	2.50	0.06	1.3	NA	6.9	342.0	144.0	168.0	375.0	307.0	31.7	94.4	56.2	1525
EPA3	10/31/94	4.94	6.19	<0.1	3.4	<0.5	7.1	0.08	<0.05	2.66	<0.05	<0.5	NA	18.5	242.0	118.0	144.0	300.0	216.0	44.5	101.0	64.0	1248
EPA3	11/11/94	5.25	6.21	<0.1	3.0	3.0	9.3	<0.05	<0.05	3.25	<0.05	0.7	NA	48.2	572.0	275.0	313.0	677.0	455.0	86.1	205.0	121.0	2752
EPA3	11/30/94	5.45	6.06	0.4	3.2	1.1	9.2	<0.05	<0.05	3.89	<0.05	<0.5	NA	41.4	501.0	306.0	399.0	793.0	465.0	86.1	207.0	131.0	2870
EPA3	12/12/94	5.12	6.18	0.1	3.3	1.2	8.7	<0.05	<0.05	3.83	<0.05	0.6	NA	88.2	395.0	302.0	325.0	737.0	300.0	58.5	149.0	93.7	2448
EPA3	12/29/94	5.31	6.21	0.1	3.3	1.0	8.4	<0.05	<0.05	4.31	<0.05	<0.5	NA	287.0	414.0	664.0	687.0	1510.0	342.0	89.4	269.0	158.0	4420
EPA3	1/9/95	5.51	6.16	0.2	2.9	1.1	8.7	<0.05	<0.05	3.57	<0.05	<0.5	NA	138.0	390.0	487.0	517.0	1190.0	432.0	98.2	264.0	156.0	3672
EPA3	1/24/95	4.75	6.55	0.2	1.2	<0.5	7.6	0.11	0.36	1.1	<0.05	6.9	NA	52.6	95.1	166.0	217.0	512.0	255.0	65.7	164.0	95.9	1623
EPA3	2/6/95	5.44	6.38	NA	2.4	<0.5	8.2	<0.05	<0.05	2.82	<0.05	<0.5	NA	105.0	102.0	338.0	364.0	882.0	341.0	78.8	213.0	118.0	2542
EPA3	2/21/95	5.16	6.41	0.1	3.9	1.6	8.4	<0.05	<0.05	2.74	<0.05	0.7	NA	269.0	119.0	749.0	736.0	1680.0	257.0	114.0	334.0	175.0	4433
EPA3	3/6/95	5.85	6.45	0.1	2.5	NA	7.6	<0.05	<0.05	2.77	<0.05	<0.5	NA	182.0	335.0	673.0	688.0	1560.0	399.0	113.0	332.0	181.0	4463
EPA3	3/22/95	5.45	6.43	0.1	1.7	1.8	8.5	0.08	<0.05	2.51	<0.05	<0.5	1.0	156.0	908.0	656.0	658.0	1570.0	692.0	113.0	308.0	176.0	5237

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S ₂ O ₃ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEXTMB (ug/L)	
EPA3	4/3/95	5.02	6.44	0.1	1.5	0.9	8.9	<0.05	<0.05	1.98	<0.05	0.7	<0.5	93.0	223.0	405.0	416.0	961.0	315.0	84.4	220.0	121.0	2838	
EPA3	4/17/95	4.83	6.60	<0.1	0.9	<0.5	5.3	1.93	0.45	0.78	<0.05	6.1	<0.5	15.5	109.0	102.0	125.0	302.0	167.0	23.7	65.3	38.7	948	
EPA3	4/28/95	4.32	6.57	0.1	0.6	<0.5	4.4	1.44	0.43	0.80	<0.05	7.9	<0.5	4.8	45.7	24.5	51.6	66.3	136.0	13.0	49.6	32.1	424	
EPA3	5/12/95	3.05	6.54	0.2	1.2	<0.5	6.7	0.15	<0.05	1.45	<0.05	2.8	<0.5	1.0	25.3	19.8	27.8	52.9	64.6	6.0	20.7	13.8	232	
EPA3	4/20/96	5.00	6.04	<0.1	<0.1	<0.5	10.1	0.50	0.50	2.42	<0.05	3.5	<0.5	2.7	305.0	685.0	786.0	1750.0	551.0	136.0	569.0	189.0	4976	
EPA4	3/30/94	6.67	5.80	0.2	4.9	<0.5	2.4	0.06	<0.05	0.81	<0.05	2.0	NA	30.0	4120.0	974.0	1610.0	3980.0	2810.0	298.0	1120.0	329.0	15271	
EPA4	4/7/94	6.84	6.18	<0.1	3.9	2.0	3.1	<0.05	<0.05	0.60	<0.05	1.4	NA	14.8	2090.0	563.0	1050.0	2970.0	1640.0	230.0	804.0	232.0	9594	
EPA4	4/11/94	6.54	6.01	<0.1	7.6	2.3	4.1	0.29	<0.05	1.58	0.10	1.6	NA	62.1	6380.0	1680.0	2970.0	6560.0	5340.0	436.0	1580.0	570.0	25578	
EPA4	4/14/94	6.34	6.06	0.1	7.3	2.1	6.5	0.11	<0.05	2.30	<0.05	3.6	NA	62.0	5860.0	1620.0	2680.0	5940.0	5130.0	466.0	1640.0	596.0	23994	
EPA4	4/18/94	6.36	6.40	<0.1	4.5	<0.5	19.7	<0.05	<0.05	0.88	<0.05	12.9	NA	37.7	3870.0	1350.0	2640.0	5430.0	4820.0	733.0	2540.0	802.0	22223	
EPA4	4/21/94	6.38	6.50	<0.1	4.5	<0.5	63.2	0.48	0.14	0.36	<0.05	20.2	NA	10.2	1780.0	970.0	2040.0	4340.0	3900.0	574.0	1760.0	675.0	16049	
EPA4	4/25/94	6.51	6.58	<0.1	3.0	<0.5	79.6	0.25	<0.05	<0.05	<0.05	23.5	NA	1.9	687.0	534.0	1490.0	2920.0	2930.0	381.0	1110.0	540.0	10594	
EPA4	5/2/94	6.34	6.33	0.1	1.1	<0.5	90.5	<0.05	<0.05	<0.05	<0.05	21.4	NA	<1.0	419.0	1230.0	998.0	1780.0	1610.0	327.0	839.0	487.0	6435	
EPA4	5/16/94	6.81	6.25	<0.1	1.2	<0.5	44.6	<0.05	<0.05	<0.05	<0.05	13.2	NA	<1.0	114.0	280.0	998.0	1780.0	1610.0	327.0	839.0	487.0	5225	
EPA4	5/31/94	6.75	6.60	0.2	1.0	1.7	8.8	<0.05	<0.05	<0.05	<0.05	9.0	NA	<1.0	53.3	145.0	627.0	1100.0	1320.0	307.0	783.0	468.0	4827	
EPA4	6/13/94	6.43	6.41	<0.1	0.3	1.7	26.5	<0.05	<0.05	<0.05	<0.05	NA	NA	<1.0	33.6	157.0	714.0	1380.0	1340.0	244.0	664.0	361.0	4894	
EPA4	6/27/94	5.30	6.26	0.1	0.9	2.7	8.2	<0.05	<0.05	<0.05	<0.05	5.4	NA	3.0	4630.0	1240.0	1930.0	3800.0	3360.0	220.0	735.0	343.0	16161	
EPA4	7/11/94	4.46	6.54	<0.1	0.6	1.1	8.2	<0.05	<0.05	<0.05	<0.05	0.6	NA	52.9	7820.0	2260.0	3370.0	7270.0	5310.0	529.0	2020.0	639.0	29271	
EPA4	7/25/94	4.84	5.92	<0.1	4.9	3.2	5.4	<0.05	<0.05	2.25	<0.05	3.2	NA	22.7	5880.0	1560.0	2380.0	5290.0	4410.0	512.0	1700.0	563.0	22318	
EPA4	8/8/94	4.18	5.91	<0.1	7.6	3.0	5.6	<0.05	<0.05	0.75	<0.05	4.8	NA	54.2	6480.0	1980.0	3610.0	8590.0	7690.0	750.0	3190.0	947.0	33291	
EPA4	8/23/94	5.93	5.80	<0.1	6.5	1.2	4.8	0.29	<0.05	1.77	<0.05	2.9	NA	17.7	1630.0	546.0	1080.0	2540.0	1910.0	471.0	1450.0	642.0	10287	
EPA4	9/19/94	5.81	6.40	0.1	4.3	2.3	9.9	0.12	<0.05	0.75	<0.05	6.0	NA	<1.0	32.3	59.8	328.0	325.0	429.0	287.0	637.0	443.0	2741	
EPA4	10/3/94	4.23	6.23	0.3	2.4	2.6	11.1	0.08	<0.05	0.71	<0.05	5.3	NA	<1.0	1040.0	277.0	755.0	1400.0	1450.0	377.0	970.0	568.0	6838	
EPA4	10/17/94	5.79	6.33	<0.1	1.8	<0.5	8.2	0.16	<0.05	0.71	<0.05	3.7	NA	<1.0	12.5	39.2	179.0	307.0	274.0	307.0	505.0	434.0	2046	
EPA4	10/31/94	5.79	6.28	<0.1	1.5	2.2	9.7	<0.05	<0.05	0.08	<0.05	2.2	NA	<1.0	6.2	33.9	179.0	307.0	274.0	274.0	307.0	505.0	434.0	2046
EPA4	11/11/94	6.10	6.28	<0.1	0.8	0.8	10.4	0.07	<0.05	<0.05	<0.05	7.5	NA	<1.0	5.5	25.9	155.0	267.0	186.0	276.0	609.0	446.0	1970	
EPA4	11/30/94	6.29	6.51	0.1	0.8	1.4	9.4	<0.05	<0.05	<0.05	<0.05	9.7	NA	<1.0	1.7	16.9	89.4	158.0	145.0	302.0	464.0	343.0	1520	
EPA4	12/12/94	6.02	6.52	0.1	0.7	1.4	9.4	<0.05	<0.05	<0.05	<0.05	5.0	NA	<1.0	<1.0	5.4	27.2	38.2	43.2	247.0	216.0	195.0	772	
EPA4	12/29/94	6.19	6.67	0.1	0.2	<0.5	8.8	0.06	<0.05	<0.05	<0.05	5.0	NA	<1.0	<1.0	6.6	34.7	49.0	54.9	255.0	249.0	203.0	852	
EPA4	1/9/95	6.36	6.73	0.2	0.5	<0.5	9.2	<0.05	<0.05	<0.05	<0.05	8.9	NA	<1.0	<1.0	6.6	34.7	49.0	54.9	255.0	249.0	203.0	852	
EPA4	1/25/95	5.53	6.90	0.5	0.1	<0.5	9.3	<0.05	<0.05	<0.05	<0.05	9.0	NA	<1.0	<1.0	6.6	34.7	49.0	54.9	255.0	249.0	203.0	852	
EPA4	2/6/95	6.26	6.90	NA	<0.1	<0.5	8.6	<0.05	<0.05	<0.05	<0.05	9.0	NA	<1.0	<1.0	6.6	34.7	49.0	54.9	255.0	249.0	203.0	852	
EPA4	2/21/95	5.98	6.90	0.5	0.1	<0.5	8.4	<0.05	<0.05	<0.05	<0.05	9.4	NA	<1.0	<1.0	6.6	34.7	49.0	54.9	255.0	249.0	203.0	852	
EPA4	3/6/95	6.42	6.85	0.1	<0.1	<0.5	8.6	<0.05	<0.05	<0.05	<0.05	8.0	NA	<1.0	<1.0	6.6	34.7	49.0	54.9	255.0	249.0	203.0	852	
EPA4	3/22/95	6.26	6.75	<0.1	<0.1	1.2	8.8	0.08	<0.05	<0.05	<0.05	7.8	NA	<1.0	<1.0	6.6	34.7	49.0	54.9	255.0	249.0	203.0	852	
EPA4	4/3/95	5.85	6.64	0.2	<0.1	<0.5	8.0	<0.05	<0.05	<0.05	<0.05	8.3	NA	<1.0	<1.0	6.6	34.7	49.0	54.9	255.0	249.0	203.0	852	
EPA4	4/17/95	5.80	6.82	0.2	<0.1	1.3	8.8	<0.05	<0.05	<0.05	<0.05	7.5	NA	<1.0	<1.0	6.6	34.7	49.0	54.9	255.0	249.0	203.0	852	
EPA4	4/28/95	5.28	6.78	0.2	<0.1	1.5	7.9	0.12	<0.05	<0.05	<0.05	7.9	NA	<1.0	<1.0	6.6	34.7	49.0	54.9	255.0	249.0	203.0	852	
EPA4	5/12/95	4.18	6.70	0.1	<0.1	<0.5	9.4	0.15	<0.05	<0.05	<0.05	4.9	NA	<1.0	<1.0	6.6	34.7	49.0	54.9	255.0	249.0	203.0	852	
EPA4	5/2/95	4.18	6.70	0.1	<0.1	<0.5	9.4	0.15	<0.05	<0.05	<0.05	4.9	NA	<1.0	<1.0	6.6	34.7	49.0	54.9	255.0	249.0	203.0	852	
EPA4	4/20/96	5.90	6.16	<0.1	<0.1	<0.5	13.5	0.50	0.50	0.60	<0.05	<0.5	NA	17.3	1570.0	827.0	1290.0	3450.0	2110.0	386.0	1240.0	404.0	11294	
EPA5A	3/30/94	3.61	5.80	0.2	4.9	<0.5	2.8	<0.05	<0.05	1.31	<0.05	3.1	NA	1.3	2.0	6.6	25.2	39.1	37.9	21.9	50.6	42.9	228	
EPA5A	4/7/94	3.98	6.34	0.1	5.2	0.9	3.1	<0.05	<0.05	1.25	0.10	2.3	NA	11.3	1.7	7.9	30.4	43.1	33.3	17.5	39.4	32.9	218	
EPA5A	4/11/94	3.88	6.26	0.1	4.8	0.7	3.0	<0.05	<0.05	1.27	0.11	<0.5	NA	11.3	2.9	10.9	36.1	50.6	30.2	19.4	39.9	30.0	231	
EPA5A	4/14/94	3.65	5.91	0.1	6.0	0.8	3.7	<0.05	<0.05	1.29	0.11	1.2	NA	6.8	5.6	9.9	30.3	43.0	21.7	12.6	28.2	21.8	180	
EPA5A	4/18/94	3.66	6.04	<0.1	6.5	2.4	3.0	<																

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S ₂ O ₃ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEXTMB (ug/L)
EPA5A	6/13/94	3.58	5.87	<0.1	7.6	5.3	8.4	<0.05	1.69	0.06	5.1	NA	<1.0	<1.0	13.8	35.6	48.4	3.8	16.9	35.9	32.3	187
EPA5A	6/27/94	2.56	5.69	0.1	6.8	4.3	5.5	<0.05	2.34	0.06	NA	NA	1.4	<1.0	30.9	50.2	77.7	2.2	39.3	124.0	53.6	379
EPA5A	7/11/94	2.05	5.80	<0.1	6.6	4.5	4.8	<0.05	2.52	0.07	3.6	NA	13.4	1.4	43.9	69.9	138.0	1.0	27.4	161.0	34.0	490
EPA5A	7/25/94	2.35	5.51	0.1	6.0	7.6	8.4	<0.05	1.83	0.17	0.1	NA	3.7	2.3	12.8	31.5	45.6	2.3	24.7	88.7	33.3	245
EPA5A	8/8/94	2.05	6.20	<0.1	4.8	8.0	7.8	<0.05	3.14	0.30	<0.5	NA	2.6	7.0	31.8	78.9	84.4	1.0	21.0	104.0	29.6	360
EPA5A	8/23/94	3.11	5.74	<0.1	4.8	7.6	6.3	<0.05	2.77	0.24	1.1	NA	1.5	5.4	9.7	42.0	52.3	1.0	16.6	46.0	20.3	195
EPA5A	9/6/94	3.35	5.88	0.1	5.1	6.9	8.8	<0.05	3.52	0.19	1.1	NA	2.0	7.1	9.6	47.4	65.0	4.0	34.7	66.9	44.4	280
EPA5A	9/19/94	3.04	5.85	<0.1	5.1	6.8	8.5	<0.05	3.38	0.15	2.1	NA	2.5	11.3	7.9	51.8	46.0	1.5	26.0	61.3	37.4	246
EPA5A	10/3/94	1.99	5.95	<0.1	5.4	8.5	9.7	<0.05	3.10	0.16	1.3	NA	1.6	5.6	6.7	55.7	38.9	1.0	29.8	77.3	43.6	260
EPA5A	10/17/94	2.69	6.00	<0.1	4.8	23.9	9.8	0.06	3.43	0.28	1.4	NA	1.4	1.3	36.1	137.0	157.0	1.0	59.1	208.0	58.2	659
EPA5A	10/31/94	2.99	6.11	<0.1	3.7	3.5	7.5	0.07	2.48	0.19	1.6	NA	<1.0	1.7	12.5	42.1	71.2	<1.0	40.2	92.5	57.5	318
EPA5A	11/11/94	3.36	5.98	<0.1	4.5	3.9	7.4	<0.05	2.93	0.15	<0.5	NA	1.7	1.2	6.0	27.9	36.9	<1.0	23.9	47.8	32.8	178
EPA5A	11/30/94	3.29	6.20	<0.1	6.5	1.3	7.5	<0.05	3.60	0.08	1.3	NA	<1.0	2.1	15.2	73.0	64.9	<1.0	39.7	85.3	52.8	333
EPA5A	12/12/94	3.23	6.10	0.1	5.8	5.7	9.4	<0.05	3.11	0.08	0.6	NA	<1.0	1.8	7.5	28.6	46.7	<1.0	35.4	77.5	48.7	246
EPA5A	12/29/94	3.28	6.08	0.1	6.0	1.5	8.2	0.07	3.05	0.07	3.7	NA	<1.0	1.1	5.3	24.0	35.3	<1.0	37.0	85.5	56.1	244
EPA5A	1/9/95	3.64	6.10	<0.1	5.4	1.0	8.3	0.18	2.98	0.07	5.1	NA	<1.0	<1.0	11.5	47.8	44.3	<1.0	51.2	142.0	56.9	354
EPA5A	1/25/95	2.51	6.04	0.3	6.0	3.3	9.0	<0.05	2.48	<0.05	2.6	NA	<1.0	1.4	13.5	76.5	73.3	<1.0	50.0	171.0	66.2	452
EPA5A	2/6/95	3.71	6.30	0.1	5.6	4.1	9.5	<0.05	2.97	<0.05	1.4	NA	<1.0	1.0	16.5	91.6	80.1	<1.0	39.3	163.0	55.8	447
EPA5A	2/21/95	3.28	6.08	0.2	3.9	3.2	9.8	<0.05	3.01	<0.05	2.2	<0.5	<1.0	1.4	17.5	74.4	97.5	<1.0	40.4	131.0	63.6	425
EPA5A	3/6/95	3.90	6.22	0.1	3.9	NA	8.5	<0.05	2.37	0.06	1.6	NA	<1.0	<1.0	9.9	41.3	45.4	<1.0	43.2	130.0	57.5	327
EPA5A	3/22/95	3.55	6.16	<0.1	2.4	2.3	8.9	0.08	2.26	<0.05	2.4	<0.5	<1.0	<1.0	12.9	53.0	71.9	<1.0	44.2	123.0	61.3	366
EPA5A	4/3/95	3.15	6.12	0.1	2.8	<0.5	9.1	<0.05	2.23	0.06	2.4	<0.5	<1.0	<1.0	10.4	58.6	55.6	<1.0	49.1	162.0	62.8	399
EPA5A	4/17/95	3.14	6.15	0.1	2.0	2.2	8.7	<0.05	2.17	<0.05	1.8	<0.5	<1.0	<1.0	17.3	86.5	109.0	<1.0	58.7	217.0	68.9	557
EPA5A	4/28/95	2.68	6.03	<0.1	3.0	2.4	8.2	<0.05	3.57	0.17	0.6	<0.5	<1.0	<1.0	8.9	28.5	56.5	<1.0	27.7	69.6	42.8	234
EPA5A	5/12/95	1.86	6.04	<0.1	2.2	<0.5	5.6	0.14	1.65	0.14	2.0	<0.5	<1.0	<1.0	4.7	19.0	33.9	<1.0	25.1	56.6	35.7	175
EPA5A	4/20/96	2.89	6.40	<0.1	<0.1	<0.5	8.7	0.50	0.82	0.07	6.3	<0.5	<1.0	<1.0	4.7	19.0	33.9	<1.0	25.1	56.6	35.7	175
EPA5B	3/30/94	3.77	5.90	<0.1	15.2	<0.5	3.5	<0.05	2.91	<0.05	<0.5	NA	20.5	3.0	43.6	99.2	93.4	3.8	17.5	144.0	28.8	454
EPA5B	4/7/94	4.21	6.27	0.2	12.7	3.0	3.0	<0.05	0.06	0.24	1.0	NA	17.1	3.0	46.9	113.0	121.0	7.0	20.3	152.0	32.0	512
EPA5B	4/11/94	4.03	6.25	0.1	8.9	<0.56	1.1	0.11	2.65	0.27	<0.5	NA	16.1	3.7	49.8	126.0	132.0	7.5	23.5	173.0	36.5	568
EPA5B	4/14/94	3.75	5.96	0.1	7.7	1.1	3.8	<0.05	2.63	0.19	<0.5	NA	16.6	3.9	50.8	119.0	137.0	9.8	23.0	157.0	36.4	554
EPA5B	4/18/94	3.80	6.30	<0.1	6.6	2.0	3.0	<0.05	2.69	0.14	1.0	NA	18.0	5.0	48.6	115.0	239.0	7.7	23.7	150.0	36.7	644
EPA5B	4/21/94	3.81	6.13	<0.1	6.8	0.7	2.8	<0.05	2.62	0.12	1.4	NA	19.9	4.1	50.7	129.0	156.0	8.2	27.3	173.0	40.5	609
EPA5B	4/25/94	3.90	6.12	0.1	7.7	3.0	2.9	<0.05	2.63	0.17	1.9	NA	18.2	3.6	49.6	127.0	159.0	8.9	26.9	161.0	38.3	592
EPA5B	5/2/94	3.70	5.97	0.1	5.3	2.8	3.1	<0.05	2.52	0.18	<0.5	NA	15.8	2.8	43.0	117.0	166.0	5.9	26.5	142.0	39.2	558
EPA5B	5/16/94	4.12	6.12	0.1	14.8	1.0	2.5	<0.05	2.50	0.15	<0.5	NA	14.0	1.5	36.5	103.0	151.0	1.4	28.1	155.0	45.0	536
EPA5B	5/31/94	4.02	5.98	<0.1	9.5	1.5	3.7	0.12	2.95	0.11	2.3	NA	21.4	1.1	30.0	103.0	129.0	<1.0	35.3	160.0	44.4	524
EPA5B	6/13/94	3.74	6.37	0.1	11.9	3.0	2.9	<0.05	2.96	0.12	0.8	NA	27.2	1.1	15.4	62.6	61.8	<1.0	29.4	157.0	34.3	389
EPA5B	6/27/94	2.76	5.84	0.1	6.6	4.0	0.7	<0.05	3.18	0.18	NA	NA	1.4	<1.0	30.3	51.4	76.8	2.5	37.4	120.0	53.5	373
EPA5B	7/11/94	2.22	5.91	0.1	9.5	2.4	2.4	<0.05	3.09	0.09	1.6	NA	47.4	2.1	18.5	31.9	14.7	<1.0	9.0	135.0	8.8	268
EPA5B	7/25/94	2.56	5.76	<0.1	10.5	8.2	3.7	<0.05	3.24	0.13	0.4	NA	50.9	2.3	24.6	29.6	30.5	2.6	10.6	196.0	15.4	363
EPA5B	8/8/94	2.24	5.71	0.1	8.6	9.5	5.0	<0.05	3.29	0.14	0.7	NA	35.4	1.8	21.2	25.2	22.4	1.9	12.7	239.0	22.4	382
EPA5B	8/23/94	3.33	5.77	<0.1	11.6	8.9	6.0	<0.05	3.41	0.14	0.4	NA	22.7	1.6	18.6	26.2	43.1	1.0	15.1	204.0	16.1	348
EPA5B	9/6/94	3.59	5.91	0.1	10.2	9.5	7.1	<0.05	3.47	0.14	0.8	NA	13.8	1.2	10.6	21.6	11.3	1.0	12.2	182.0	14.6	268
EPA5B	9/19/94	3.26	6.04	<0.1	8.9	10.3	7.9	<0.05	3.35	0.14	<0.5	NA	10.0	1.0	11.7	33.9	28.0	<1.0	9.5	186.0	19.5	300
EPA5B	10/3/94	2.16	5.94	0.1	10.9	11.3	8.5	<0.05	3.62	0.15	1.5	NA	8.6	1.0	14.0	39.4	28.4	1.0	20.6	180.0	25.0	318
EPA5B	10/17/94	2.93	6.01	<0.1	12.7	14.4	8.8	0.07	3.71	0.15	2.0	NA	7.7	1.0	9.3	37.8	28.8	<1.0	10.9	154.0	15.6	265
EPA5B	10/31/94	3.24	6.01	0.1	11.6	14.1	8.3	0.08	3.45	0.18	1.0	NA	5.4	<1.0	7.9	39.9	5.7	<1.0	7.3	176.0	16.5	259
EPA5B	11/11/94	3.60	6.02	0.1	12.3	13.3	8.9	<0.05	3.58	0.18	<0.5	NA	4.9	<1.0	5.6	26.2	2.1	<1.0	14.5	171.0	14.1	238
EPA5B	11/30/94	3.55	6.11	<0.1	10.2	10.1	9.0	<0.05	3.71	0.18	1.2	NA	3.6	<1.0	5.6	18.5	4.9	<1.0	4.9	112.0	9.0	154
EPA5B	12/12/94	3.48	6.23	0.1	13.5	10.1	9.2	<0.05	3.77	0.16	<0.5	NA	2.5	<1.0	10.1	31.0	32.6	<1.0	4.9	148.0	22.5	252
EPA5B	12/29/94	3.60	6.17	0.1	15.0	9.3	8.5	<0.05	4.00	0.17	<0.5	NA	2.2	<1.0	5.3	14.3	5.3	<1.0	6.2	139.0	18.7	191
EPA5B	1/9/95	3.88	6.16	0.1	14.8	8.2	10.3	<0.05	3.67													

APPENDIX C (cont.)

EPAP-CL1	3/30/94	NA	6.30	<0.1	11.9	<0.5	3.3	<0.05	2.88	1.51	3.1	NA	<1.0	63.5	50.6	108.0	207.0	<1.0	149.0	275.0	136.0	989
EPAP-CL1	4/7/94	NA	6.72	0.1	5.8	1.0	2.1	<0.05	<0.05	3.91	1.31	6.8	NA	<1.0	58.2	51.7	119.0	199.0	<1.0	135.0	265.0	951
EPAP-CL1	4/11/94	NA	6.26	0.1	4.8	2.1	6.6	0.73	<0.05	4.76	1.22	11.6	NA	<1.0	63.0	53.6	110.0	226.0	<1.0	152.0	280.0	1038
EPAP-CL1	4/14/94	NA	6.08	0.1	1.7	11.1	16.6	1.97	<0.05	5.30	0.96	32.2	NA	<1.0	60.9	57.7	117.0	239.0	1.7	155.0	272.0	1054
EPAP-CL1	4/18/94	NA	6.40	<0.1	8.9	35.3	13.4	2.11	0.14	5.36	0.83	41.8	NA	<1.0	55.1	55.1	110.0	229.0	1.5	149.0	258.0	1003

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S ₂ O ₃ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEXTMB (ug/L)
EPA1-CL1	4/21/94	NA	6.34	0.4	7.6	39.4	11.7	0.23	0.21	5.47	0.36	39.5	NA	<1.0	57.5	55.5	115.0	229.0	2.0	152.0	264.0	153.0	1028
EPA1-CL1	4/25/94	NA	6.33	0.1	6.2	43.9	10.8	0.26	0.20	4.89	0.38	30.7	NA	<1.0	50.9	54.6	112.0	229.0	1.8	141.0	248.0	143.0	980
EPA1-CL1	5/2/94	NA	6.12	0.1	7.3	53.9	10.1	<0.05	<0.05	3.61	1.23	5.1	NA	<1.0	44.0	49.7	102.0	203.0	2.3	139.0	235.0	133.0	908
EPA1-CL1	5/16/94	NA	6.34	0.3	6.2	10.9	9.0	<0.05	<0.05	3.72	1.44	1.2	NA	<1.0	32.5	42.9	83.6	171.0	2.4	115.0	190.0	114.0	751
EPA1-CL1	5/31/94	NA	6.19	<0.1	4.8	3.1	12.7	0.17	<0.05	6.67	1.35	4.8	NA	<1.0	30.6	48.5	89.6	168.0	2.0	130.0	210.0	119.0	795
EPA1-CL1	6/13/94	NA	5.98	<0.1	4.9	2.0	8.8	<0.05	<0.05	5.42	1.53	4.1	NA	<1.0	33.6	45.9	95.9	188.0	2.1	132.0	228.0	132.0	860
EPA1-CL1	6/27/94	NA	5.85	0.2	5.1	61.9	10.4	<0.05	<0.05	4.93	1.25	NA	NA	<1.0	30.0	50.6	101.0	188.0	4.5	135.0	260.0	135.0	904
EPA1-CL1	7/11/94	NA	6.05	<0.1	4.9	6.9	8.8	<0.05	<0.05	2.88	1.57	1.2	NA	<1.0	17.5	37.1	71.6	138.0	4.3	119.0	181.0	110.0	679
EPA1-CL1	7/25/94	NA	5.55	<0.1	4.1	2.6	8.8	<0.05	<0.05	1.79	1.60	<0.5	NA	<1.0	14.4	35.5	71.0	124.0	5.1	118.0	200.0	114.0	692
EPA1-CL1	8/8/94	NA	5.62	<0.1	5.1	3.2	10.0	<0.05	<0.05	2.11	1.50	<0.5	NA	<1.0	15.5	36.9	76.3	147.0	4.3	125.0	198.0	119.0	722
EPA1-CL1	8/23/94	NA	5.75	<0.1	5.2	1.1	11.5	<0.05	<0.05	3.01	1.31	<0.5	NA	<1.0	12.9	33.4	71.6	141.0	4.9	120.0	184.0	105.0	673
EPA1-CL1	9/6/94	NA	5.77	0.1	6.0	2.6	11.2	<0.05	<0.05	3.07	1.47	<0.5	NA	<1.0	13.0	35.2	74.1	147.0	6.0	119.0	174.0	104.0	672
EPA1-CL1	9/19/94	NA	5.87	0.1	5.2	2.0	10.7	0.08	<0.05	2.81	1.72	2.0	NA	<1.0	9.9	35.0	70.1	131.0	5.4	116.0	187.0	110.0	664
EPA1-CL1	10/3/94	NA	6.10	<0.1	3.1	<0.5	10.5	0.51	0.08	2.84	1.66	7.0	NA	<1.0	6.9	32.1	67.2	120.0	4.4	121.0	189.0	117.0	658
EPA1-CL1	10/17/94	NA	6.21	0.1	3.0	<0.5	9.7	0.08	<0.05	2.20	1.47	3.9	NA	<1.0	5.7	30.7	64.9	110.0	3.6	122.0	187.0	107.0	631
EPA1-CL1	10/31/94	NA	6.27	<0.1	3.0	<0.5	8.8	<0.05	<0.05	1.49	1.40	4.6	NA	<1.0	5.4	30.7	63.2	112.0	3.2	125.0	199.0	109.0	648
EPA1-CL1	11/11/94	NA	6.24	0.1	2.6	1.1	9.1	<0.05	<0.05	1.18	1.40	1.8	NA	<1.0	5.0	28.0	61.1	106.0	2.6	124.0	195.0	109.0	631
EPA1-CL1	11/30/94	NA	6.40	<0.1	3.1	<0.5	9.1	4.09	0.27	1.30	1.10	12.5	NA	<1.0	4.3	27.8	56.3	116.0	2.8	97.7	156.0	99.4	560
EPA1-CL1	12/12/94	NA	6.46	0.2	2.7	1.1	7.7	0.13	0.17	0.91	1.17	6.7	NA	<1.0	4.4	31.2	55.6	110.0	1.9	104.0	172.0	99.2	570
EPA1-CL1	12/29/94	NA	6.23	0.3	2.5	<0.5	9.1	1.90	1.44	0.78	0.62	10.9	NA	<1.0	3.0	26.3	53.3	106.0	1.7	94.5	178.0	95.9	557
EPA1-CL1	1/9/95	NA	6.49	0.2	1.7	<0.5	9.4	2.56	1.46	0.63	0.53	11.2	NA	<1.0	2.6	25.1	53.3	106.0	1.7	94.5	178.0	95.9	557
EPA1-CL1	1/25/95	NA	6.80	NA	1.4	<0.5	9.1	1.22	1.61	0.36	0.44	9.6	NA	<1.0	1.8	22.5	52.9	88.8	1.4	80.2	182.0	104.0	534
EPA1-CL1	2/6/95	NA	6.72	<0.1	0.9	<0.5	8.6	1.26	1.95	0.93	0.38	9.8	NA	<1.0	1.0	15.1	36.9	54.4	1.2	55.3	151.0	90.6	406
EPA1-CL1	2/21/95	NA	6.81	<0.1	0.8	<0.5	8.3	2.08	2.72	0.81	0.48	10.1	<0.5	<1.0	1.0	15.2	41.7	52.7	1.1	52.2	173.0	102.0	439
EPA1-CL1	3/6/95	NA	6.68	0.1	0.9	<0.5	9.7	7.52	0.10	0.62	0.27	10.2	NA	<1.0	<1.0	10.3	33.3	28.3	1.0	36.5	162.0	90.5	361
EPA1-CL1	3/22/95	NA	6.55	0.2	1.8	<0.5	9.1	<0.05	0.86	0.56	0.69	7.7	<0.5	<1.0	<1.0	10.3	33.8	29.4	1.0	33.1	162.0	90.5	366
EPA1-CL1	4/3/95	NA	6.54	0.1	2.7	<0.5	9.1	<0.05	<0.05	0.90	1.15	5.5	<0.5	<1.0	<1.0	12.8	38.4	38.0	1.0	39.2	181.0	107.0	417
EPA1-CL1	4/17/95	NA	6.57	<0.1	2.5	0.8	8.5	<0.05	<0.05	1.28	1.22	9.8	<0.5	<1.0	<1.0	13.9	40.1	43.0	<1.0	44.4	192.0	115.0	448
EPA1-CL1	4/28/95	NA	6.56	0.1	2.5	<0.5	9.0	<0.05	<0.05	1.29	1.22	9.0	<0.5	<1.0	<1.0	12.2	32.5	41.0	<1.0	39.8	158.0	88.2	372
EPA1-CL1	5/12/95	NA	6.49	0.2	1.7	<0.5	10.2	<0.05	<0.05	1.08	1.16	0.6	<0.5	<1.0	<1.0	11.3	32.0	41.3	<1.0	42.7	153.0	84.1	364
EPA1-CL1	4/21/96	NA	6.37	0.1	<0.1	<0.5	4.2	0.50	0.85	0.85	1.79	<0.5	<0.5	<1.0	1.6	23.8	54.3	89.9	<1.0	69.2	177.0	100.0	516
EPA1-CL2	3/30/94	NA	6.30	0.1	3.7	<0.5	2.7	<0.05	<0.05	2.01	0.79	<0.5	NA	<1.0	5.7	29.4	56.4	67.4	25.1	25.6	74.3	42.8	327
EPA1-CL2	4/7/94	NA	6.70	0.1	6.5	<0.5	1.9	<0.05	<0.05	2.03	0.74	0.9	NA	<1.0	7.7	27.1	52.3	64.4	25.7	24.8	71.3	42.4	316
EPA1-CL2	4/11/94	NA	6.37	<0.1	1.8	0.7	1.6	<0.05	<0.05	2.45	0.91	3.7	NA	<1.0	17.0	29.3	60.4	71.2	12.0	27.0	71.3	38.7	327
EPA1-CL2	4/14/94	NA	6.19	0.2	2.3	7.6	14.5	4.78	<0.05	4.36	0.73	25.8	NA	<1.0	41.9	44.3	79.4	109.0	38.9	38.1	106.0	52.2	510
EPA1-CL2	4/18/94	NA	6.54	<0.1	3.0	22.7	12.3	4.40	0.14	4.53	0.66	31.5	NA	<1.0	19.8	32.2	64.3	74.3	9.7	37.4	96.5	49.3	384
EPA1-CL2	4/21/94	NA	6.30	0.2	3.0	38.8	11.8	2.54	0.44	5.19	<0.05	43.4	NA	<1.0	20.4	31.7	63.0	75.0	11.1	34.4	83.8	44.6	364
EPA1-CL2	4/25/94	NA	6.46	0.4	2.7	41.4	9.0	0.67	0.48	4.11	0.26	33.5	NA	<1.0	18.8	29.7	65.4	76.6	8.9	31.4	95.4	48.0	374
EPA1-CL2	5/2/94	NA	6.16	0.1	2.6	46.2	9.3	<0.05	<0.05	4.04	0.97	12.2	NA	<1.0	7.6	30.4	61.2	73.0	11.2	32.3	82.3	41.8	340
EPA1-CL2	5/16/94	NA	6.30	<0.1	3.0	11.1	8.9	<0.05	<0.05	4.25	1.10	3.4	NA	<1.0	31.5	65.2	127.0	153.0	21.6	65.0	153.0	78.7	695
EPA1-CL2	5/31/94	NA	6.11	0.1	3.0	2.5	12.6	0.69	<0.05	6.52	1.16	11.5	NA	<1.0	8.9	26.7	57.8	57.0	7.6	21.7	121.0	54.6	355
EPA1-CL2	6/13/94	NA	5.83	<0.1	2.9	3.0	8.0	0.50	<0.05	2.09	1.12	10.0	NA	<1.0	4.6	19.0	51.0	40.9	4.4	9.9	108.0	50.7	289
EPA1-CL2	6/27/94	NA	5.85	0.2	2.7	120.0	12.8	11.30	<0.05	0.92	0.24	NA	NA	<1.0	1.0	12.9	40.8	17.1	9.9	4.7	94.3	45.0	226
EPA1-CL2	7/1/94	NA	6.04	0.1	1.5	2.3	6.7	<0.05	<0.05	0.59	0.71	1.5	NA	<1.0	<1.0	9.5	26.0	15.4	3.4	3.3	28.0	27.3	113
EPA1-CL2	7/25/94	NA	5.82	<0.1	2.0	0.9	9.5	<0.05	<0.05	0.65	0.89	3.1	NA	<1.0	<1.0	13.6	35.7	19.6	5.1	6.8	58.6	40.3	181
EPA1-CL2	8/8/94	NA	5.92	<0.1	1.6	2.5	10.6	<0.05	<0.05	1.13	0.84	<0.5	NA	<1.0	1.4	13.7	34.9	21.0	4.1	6.0	40.3	31.3	153
EPA1-CL2	8/23/94	NA	5.96	<0.1	2.5	1.8	15.3	<0.05	<0.05	3.04	0.79	<0.5	NA	<1.0	1.0	11.2	28.2	17.7	3.3	5.3	24.6	20.8	112
EPA1-CL2	9/6/94	NA	6.08	0.2	2.1	1.9	12.5	<0.05	<0.05	3.13	0.86	1.3	NA	<1.0	1.0	11.0	31.1	22.5	3.3	4.7	18.9	18.9	111
EPA1-CL2	9/19/94	NA	6.04	0.4	2.4	1.2	10.6	<0.05	<0.05	2.96	1.24	1.6	NA	<1.0	2.0	13.1	40.5	27.6	2.7	21.6	29.0	23.9	160
EPA1-CL2	10/3/94	NA	6.36	<0.1	0.6	<0.5	10.8	2.20	1.43	1.94	0.92	12.0	NA	<1.0	1.0	10.9	33.8	17.7	1.6	20.5	21.1	21.5	128
EPA1-CL2	10/17/94	NA	6.48	0.1	0.5	<0.5	9.2	0.25	1.60	0.65	0.44	11.5	NA	<1.0	<1.0	4.0	26.7	9.9	1.0	2.6	21.1	26.9	92
EPA1-CL2	10/31/94	NA	6.52	<0.1	0.4	<0.5	8.7	2.18	4.16	0.38	0.46	10.6	NA	<1.0	<1.0	2.9	30.9	5.0	1.7	16.6	59.8	42.2	159

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S ₂ O ₃ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MYXL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEXTMB (ug/L)	
EPA1-CL2	11/11/94	NA	6.57	0.2	0.4	0.9	8.5	0.18	0.29	0.26	0.67	8.8	NA	<1.0	<1.0	2.8	30.2	6.2	1.5	18.3	52.2	32.6	144	
EPA1-CL2	11/30/94	NA	6.52	<0.1	<0.1	<0.5	10.1	5.22	1.85	0.50	0.49	14.0	NA	<1.0	1.0	5.6	31.3	3.7	1.3	1.1	48.2	37.6	130	
EPA1-CL2	12/12/94	NA	6.61	<0.1	0.7	0.9	7.9	<0.05	0.13	0.38	0.94	8.9	NA	<1.0	<1.0	9.0	42.0	8.9	1.0	1.9	37.2	28.5	129	
EPA1-CL2	12/29/94	NA	6.42	0.2	0.2	<0.5	9.2	1.43	1.95	0.53	0.40	12.3	NA	<1.0	1.8	9.7	38.8	12.1	1.0	2.3	33.5	27.1	126	
EPA1-CL2	1/9/95	NA	6.70	0.3	<0.1	<0.5	9.2	3.38	5.72	<0.05	0.22	11.2	NA	<1.0	<1.0	5.7	33.6	4.6	<1.0	1.8	33.2	29.7	109	
EPA1-CL2	1/25/95	NA	6.75	NA	<0.1	<0.5	9.1	1.52	6.06	0.24	0.27	11.0	NA	<1.0	1.3	7.5	39.7	10.4	1.3	3.8	65.5	35.9	165	
EPA1-CL2	2/6/95	NA	6.88	<0.1	<0.1	<0.5	8.2	1.47	4.89	0.41	0.30	10.3	NA	<1.0	1.4	6.0	29.2	8.2	1.3	2.6	46.5	23.2	118	
EPA1-CL2	2/21/95	NA	6.92	<0.1	<0.1	<0.5	8.6	4.80	7.74	0.07	0.37	10.7	<0.5	<1.0	1.6	7.2	31.2	10.8	1.0	8.1	117.0	50.5	227	
EPA1-CL2	3/6/95	NA	6.96	0.2	<0.1	<0.5	10.6	8.80	0.08	0.34	0.34	12.8	NA	<1.0	1.1	5.0	19.8	7.9	<1.0	7.3	105.0	48.1	194	
EPA1-CL2	3/22/95	NA	6.67	0.3	<0.1	<0.5	8.7	0.51	6.44	0.39	0.43	11.6	<0.5	<1.0	1.0	4.8	18.7	7.0	<1.0	8.2	106.0	48.4	194	
EPA1-CL2	4/3/95	NA	6.80	0.1	<0.1	<0.5	9.4	0.40	4.33	0.76	0.45	15.7	<0.5	<1.0	<1.0	3.6	15.1	3.8	<1.0	5.8	80.9	41.9	151	
EPA1-CL2	4/17/95	NA	6.80	<0.1	0.5	<0.5	8.3	<0.05	<0.05	1.03	0.88	1.0	<0.5	<1.0	2.2	9.2	41.8	8.4	<1.0	6.8	70.0	11.3	150	
EPA1-CL2	4/28/95	NA	6.90	0.1	0.2	<0.5	10.1	<0.05	<0.05	0.82	0.99	1.3	1.2	<1.0	1.1	3.9	19.3	4.2	<1.0	3.6	36.0	20.6	89	
EPA1-CL2	5/12/95	NA	6.84	<0.1	<0.1	<0.5	11.2	0.20	<0.05	0.75	1.01	4.3	<0.5	<1.0	1.4	5.1	23.1	5.3	<1.0	4.3	49.6	16.7	106	
EPA1-CL2	4/21/96	NA	6.74	0.3	<0.1	<0.5	2.2	0.50	0.50	0.28	1.11	<0.5	<0.5	<1.0	<1.0	2.0	5.7	4.1	1.1	3.8	41.7	24.4	83	
EPA1-CL3	3/30/94	NA	6.10	0.2	1.8	<0.5	2.8	0.37	<0.05	3.92	0.69	8.2	NA	<1.0	88.5	187.0	746.0	339.0	157.0	485.0	217.0	2613		
EPA1-CL3	4/7/94	NA	6.42	0.2	3.4	0.7	1.8	<0.05	<0.05	3.35	0.74	4.9	NA	<1.0	73.0	149.0	547.0	236.0	125.0	371.0	131.0	1931		
EPA1-CL3	4/11/94	NA	6.24	<0.1	1.0	0.4	1.8	<0.05	<0.05	3.08	0.81	<0.5	NA	<1.0	32.7	52.1	112.0	180.0	83.9	63.0	195.0	76.4	795	
EPA1-CL3	4/14/94	NA	6.08	<0.1	1.2	1.2	3.5	0.15	<0.05	3.52	0.69	4.6	NA	<1.0	52.4	55.8	99.1	164.0	53.6	51.1	158.0	69.3	703	
EPA1-CL3	4/18/94	NA	6.42	0.2	6.0	20.8	15.9	8.66	<0.05	4.91	0.47	36.9	NA	<1.0	26.3	39.0	79.5	106.0	29.1	46.5	141.0	63.2	531	
EPA1-CL3	4/21/94	NA	6.21	0.3	3.6	31.0	10.5	6.92	0.06	4.22	0.32	30.8	NA	<1.0	36.3	41.3	86.4	112.0	33.4	48.0	148.0	67.7	573	
EPA1-CL3	4/25/94	NA	6.38	<0.1	2.5	35.4	10.0	2.93	0.40	4.14	0.06	30.7	NA	<1.0	15.4	33.6	69.2	90.7	20.5	24.8	127.0	58.8	440	
EPA1-CL3	5/2/94	NA	6.22	0.3	2.2	49.2	9.3	<0.05	<0.05	3.47	0.70	17.0	NA	<1.0	2.9	22.8	55.2	63.5	9.7	8.6	112.0	52.8	328	
EPA1-CL3	5/16/94	NA	6.36	<0.1	1.7	11.8	9.3	<0.05	<0.05	3.73	1.02	5.5	NA	<1.0	4.7	23.2	55.4	58.5	11.0	33.4	129.0	57.0	372	
EPA1-CL3	5/31/94	NA	6.02	0.2	1.0	1.1	11.6	0.96	0.30	4.57	0.51	14.6	NA	<1.0	3.3	11.8	41.1	31.5	7.3	17.3	85.0	41.8	239	
EPA1-CL3	6/13/94	NA	5.71	<0.1	0.9	3.3	7.5	0.25	<0.05	1.00	0.68	8.8	NA	<1.0	<1.0	4.5	33.4	8.0	6.9	1.8	33.9	18.1	107	
EPA1-CL3	6/27/94	NA	5.84	<0.1	1.7	37.2	11.5	0.26	<0.05	3.80	0.62	NA	NA	<1.0	<1.0	7.2	32.7	9.2	23.4	2.5	49.8	38.2	163	
EPA1-CL3	7/11/94	NA	5.95	0.1	2.1	2.4	6.9	<0.05	<0.05	0.74	0.73	1.5	NA	<1.0	<1.0	10.7	31.5	40.5	41.0	5.7	104.0	53.3	287	
EPA1-CL3	7/25/94	NA	5.86	<0.1	1.6	1.3	9.4	<0.05	<0.05	0.97	0.92	8.1	NA	<1.0	<1.0	5.4	21.0	16.5	8.9	6.9	74.7	48.7	182	
EPA1-CL3	8/8/94	NA	5.91	<0.1	2.2	2.2	9.4	<0.05	<0.05	0.42	0.67	3.7	NA	<1.0	10.6	264.0	459.0	544.0	979.0	30.0	364.0	255.0	2906	
EPA1-CL3	8/23/94	NA	5.88	<0.1	2.7	2.8	11.0	<0.05	<0.05	1.87	0.60	<0.5	NA	<1.0	8.0	387.0	652.0	1450.0	1070.0	129.0	419.0	224.0	4339	
EPA1-CL3	9/6/94	NA	6.12	<0.1	3.5	1.7	8.2	<0.05	<0.05	1.57	0.65	<0.5	NA	<1.0	3.0	177.0	371.0	709.0	510.0	92.9	405.0	255.0	2523	
EPA1-CL3	9/19/94	NA	6.45	0.1	3.4	1.0	10.4	0.08	<0.05	3.75	0.77	0.8	NA	<1.0	<1.0	5.7	32.1	16.8	14.5	23.6	45.9	25.3	164	
EPA1-CL3	10/3/94	NA	6.76	<0.1	0.7	<0.5	10.9	0.08	0.68	1.38	0.89	13.1	NA	<1.0	<1.0	4.9	65.0	11.8	102.0	19.6	111.0	99.5	414	
EPA1-CL3	10/17/94	NA	6.59	<0.1	0.5	<0.5	9.3	0.12	<0.05	0.22	0.91	7.4	NA	<1.0	<1.0	2.0	15.3	5.4	5.1	17.2	26.5	30.8	102	
EPA1-CL3	10/31/94	NA	6.57	<0.1	<0.1	<0.5	9.0	<0.05	<0.05	0.51	12.1	NA	NA	<1.0	<1.0	1.6	111.0	342.0	535	500.0	9.9	379.0	262.0	1659
EPA1-CL3	11/11/94	NA	6.92	0.2	<0.1	0.8	9.0	<0.05	<0.05	0.92	0.63	5.2	NA	<1.0	<1.0	5.8	19.6	5.5	2.2	2.8	12.8	8.6	57	
EPA1-CL3	11/30/94	NA	6.91	<0.1	<0.1	<0.5	8.4	1.34	<0.05	0.66	0.65	7.7	NA	<1.0	<1.0	2.8	2.8	61.3	2.6	64.6	47.3	181		
EPA1-CL3	12/12/94	NA	7.03	<0.1	<0.1	<0.1	9.0	0.49	6.09	1.02	0.62	12.1	NA	<1.0	<1.0	1.5	9.0	2.6	5.3	2.2	68.9	52.5	142	
EPA1-CL3	12/29/94	NA	6.59	0.3	<0.1	<0.5	9.4	7.97	7.33	<0.05	<0.05	10.2	NA	<1.0	<1.0	6.1	19.7	7.6	2.3	5.5	74.4	35.4	151	
EPA1-CL3	1/9/95	NA	6.83	0.2	<0.1	<0.5	9.2	1.33	7.79	<0.05	0.57	10.8	NA	<1.0	<1.0	<1.0	3.2	2.2	3.0	2.4	50.3	28.5	90	
EPA1-CL3	1/25/95	NA	7.03	NA	<0.1	<0.5	8.5	2.67	6.76	0.61	0.59	10.4	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	71	
EPA1-CL3	2/6/95	NA	7.16	<0.1	<0.1	<0.5	7.4	0.36	5.85	0.09	0.66	9.5	NA	<1.0	<1.0	4.9	16.1	2.6	29.9	2.6	344.0	219.0	619	
EPA1-CL3	2/21/95	NA	7.04	<0.1	<0.1	<0.5	8.7	6.90	6.18	0.30	0.58	11.1	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.8	1.5	111.0	60.3	176
EPA1-CL3	3/6/95	NA	6.85	<0.1	<0.1	<0.5	7.9	26.80	0.09	0.09	0.34	12.7	NA	<1.0	<1.0	<1.0	1.7	<1.0	<1.0	2.4	10.0	7.0	34	
EPA1-CL3	3/22/95	NA	6.76	<0.1	<0.1	<0.5	8.1	0.06	0.14	0.59	0.59	7.6	<0.5	<1.0	<1.0	<1.0	4.3	9.4	<1.0	<1.0	1.4	8.9	6.7	18
EPA1-CL3	4/3/95	NA	6.95	0.1	<0.1	<0.5	7.9	<0.05	<0.05	0.77	0.73	10.0	<0.5	<1.0	<1.0	<1.0	1.3	<1.0	<1.0	1.4	19.0	9.2	31	
EPA1-CL3	4/17/95	NA	7.13	<0.1	<0.1	<0.5	8.7	5.93	4.97	3.16	12.2	<0.5	<1.0	<1.0	<1.0	<1.0	1.6	<1.0	<1.0	<1.0	1.2	13.8	9.5	26
EPA1-CL3	4/28/95	NA	7.12	<0.1	<0.1	<0.5	10.1	1.14	7.50	0.62	0.56	11.6	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.3	10.7	5.9	18
EPA1-CL3	5/12/95	NA	6.93	<0.1	<0.1	<0.5	13.0	<0.05	<0.05	0.65	0.79	11.3	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5.7	312.0	35.8	386
EPA1-CL3	4/21/96	NA	6.50	0.4	<0.1	<0.5	11.4	0.50	0.50	4.03	0.71	<0.5	<0.5	<1.0	<1.0									

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NO ₃ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S ₂ O ₃ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEXTMB (ug/L)	
EPA1-CL4	3/30/94	NA	6.10	0.1	10.5	<0.5	4.1	<0.05	<0.05	<0.05	1.87	0.36	3.0	NA	4.0	74.0	53.7	213.0	404.0	129.0	104.0	343.0	33.7	1358	
EPA1-CL4	4/7/94	NA	6.41	0.2	0.5	0.9	3.3	0.07	<0.05	<0.05	1.74	1.11	4.8	NA	1.8	30.1	69.0	289.0	554.0	203.0	94.0	256.0	46.8	1544	
EPA1-CL4	4/11/94	NA	6.22	<0.1	2.0	0.7	2.1	<0.05	<0.05	<0.05	1.63	1.44	2.7	NA	1.2	32.6	156.0	436.0	925.0	415.0	113.0	338.0	119.0	2536	
EPA1-CL4	4/14/94	NA	6.07	0.1	2.9	0.9	2.1	<0.05	<0.05	<0.05	1.66	1.36	1.3	NA	<1.0	37.4	184.0	457.0	914.0	367.0	136.0	384.0	145.0	2624	
EPA1-CL4	4/18/94	NA	6.41	0.1	3.1	1.2	2.5	0.13	<0.05	<0.05	2.20	1.31	5.1	NA	<1.0	9.1	66.5	194.0	349.0	110.0	148.0	389.0	122.0	1388	
EPA1-CL4	4/21/94	NA	6.19	0.1	4.5	8.1	17.6	4.70	<0.05	<0.05	4.15	0.28	13.4	NA	<1.0	9.3	58.8	177.0	276.0	91.4	130.0	372.0	105.0	1220	
EPA1-CL4	4/25/94	NA	6.18	0.2	6.5	45.3	15.5	12.90	0.09	<0.05	6.18	<0.05	33.0	NA	<1.0	6.5	48.5	81.9	57.3	40.3	56.6	199.0	62.9	553	
EPA1-CL4	5/16/94	NA	6.06	0.4	2.8	49.9	8.7	0.96	<0.05	<0.05	4.05	0.13	17.1	NA	<1.0	1.9	39.0	34.9	9.5	22.5	2.1	78.4	33.7	222	
EPA1-CL4	5/31/94	NA	6.38	0.1	2.6	11.7	9.1	<0.05	<0.05	<0.05	3.00	1.02	4.4	NA	<1.0	<1.0	10.8	47.6	46.8	17.2	9.9	33.1	12.9	178	
EPA1-CL4	6/13/94	NA	6.11	<0.1	0.5	1.9	10.2	0.46	<0.05	<0.05	2.52	0.48	12.5	NA	<1.0	<1.0	2.0	21.3	4.3	4.5	2.2	11.1	4.0	49	
EPA1-CL4	6/27/94	NA	5.89	0.1	1.3	1.9	7.8	<0.05	0.10	<0.05	2.42	0.81	11.6	NA	<1.0	<1.0	20.6	57.3	51.9	12.2	10.1	50.4	18.1	221	
EPA1-CL4	7/11/94	NA	5.62	<0.1	<0.1	121.0	12.9	11.40	<0.05	<0.05	0.90	0.24	NA	NA	1.4	<1.0	<1.0	3.0	111.0	7.0	206.0	1.8	45.6	38.6	414
EPA1-CL4	7/25/94	NA	5.84	<0.1	1.3	3.9	10.0	<0.05	<0.05	<0.05	0.19	0.85	6.5	NA	<1.0	1.2	78.4	216.0	235.0	473.0	13.5	295.0	200.0	1512	
EPA1-CL4	8/6/94	NA	5.74	<0.1	2.5	1.4	9.4	4.86	<0.05	<0.05	0.86	0.94	11.4	NA	<1.0	<1.0	31.6	111.0	120.0	183.0	45.0	340.0	193.0	1024	
EPA1-CL4	8/23/94	NA	5.97	0.1	1.7	2.3	9.1	<0.05	<0.05	<0.05	0.69	0.77	1.0	NA	1.4	<1.0	26.9	72.8	66.9	105.0	7.2	141.0	96.7	518	
EPA1-CL4	9/6/94	NA	5.94	<0.1	4.5	2.2	10.1	<0.05	<0.05	<0.05	1.40	0.73	<0.5	NA	1.0	<1.0	49.1	123.0	200.0	142.0	19.2	215.0	146.0	895	
EPA1-CL4	9/19/94	NA	6.18	<0.1	3.3	1.8	10.9	<0.05	<0.05	<0.05	2.44	0.81	<0.5	NA	<1.0	<1.0	49.2	132.0	221.0	187.0	76.3	277.0	157.0	1100	
EPA1-CL4	10/3/94	NA	6.31	<0.1	1.5	<0.5	10.6	0.81	<0.05	<0.05	3.89	1.19	9.1	NA	1.0	1.5	15.8	53.5	27.5	4.6	15.0	56.1	31.5	207	
EPA1-CL4	10/17/94	NA	6.59	<0.1	<0.1	<0.5	8.5	0.48	0.33	0.67	0.48	11.4	10.4	NA	<1.0	<1.0	1.0	8.5	2.8	7.4	2.1	38.2	45.7	107	
EPA1-CL4	10/31/94	NA	6.57	<0.1	<0.1	<0.5	9.0	0.57	0.31	0.43	0.49	10.4	10.4	NA	<1.0	<1.0	<1.0	5.4	1.8	1.8	13.3	31.0	26.1	79	
EPA1-CL4	11/11/94	NA	6.67	0.1	<0.1	0.8	8.7	2.41	4.71	0.30	0.47	10.2	10.2	NA	<1.0	<1.0	<1.0	16.9	2.4	41.3	13.9	16.8	18.9	110	
EPA1-CL4	11/30/94	NA	6.70	<0.1	<0.1	<0.5	9.3	11.90	0.61	<0.05	<0.05	0.46	10.9	NA	<1.0	<1.0	<1.0	1.8	1.2	1.5	1.0	14.9	17.5	38	
EPA1-CL4	12/12/94	NA	6.79	0.1	<0.1	1.1	8.6	2.73	7.08	<0.05	<0.05	0.47	10.1	NA	<1.0	<1.0	<1.0	6.8	1.6	1.1	2.1	48.3	35.0	95	
EPA1-CL4	12/29/94	NA	6.51	0.1	<0.1	<0.5	9.1	7.50	3.50	<0.05	<0.05	0.46	10.6	NA	<1.0	<1.0	5.9	23.9	13.2	<1.0	1.7	61.4	30.0	137	
EPA1-CL4	1/9/95	NA	6.70	0.1	<0.1	<0.5	9.3	4.36	3.60	0.43	0.48	9.9	9.9	NA	<1.0	2.2	9.4	39.5	15.3	<1.0	8.7	132.0	63.7	271	
EPA1-CL4	1/25/95	NA	6.75	0.9	<0.1	<0.5	9.4	2.79	9.91	<0.05	<0.05	0.43	10.5	NA	<1.0	<1.0	<1.0	6.3	1.3	<1.0	1.5	58.5	30.0	98	
EPA1-CL4	2/6/95	NA	6.88	<0.1	<0.1	<0.5	7.8	<0.05	5.13	0.20	0.48	9.8	9.8	NA	<1.0	<1.0	<1.0	1.1	<1.0	<1.0	<1.0	16.9	16.5	35	
EPA1-CL4	2/21/95	NA	6.93	0.1	<0.1	<0.5	8.6	5.40	8.85	0.12	0.57	10.7	10.7	NA	<1.0	<1.0	<1.0	1.1	1.0	1.2	1.0	24.5	19.4	48	
EPA1-CL4	3/6/95	NA	6.92	0.2	<0.1	<0.5	8.7	16.00	0.09	0.15	0.45	12.7	12.7	NA	<1.0	<1.0	2.7	6.9	2.0	58.6	1.0	236.0	197.0	504	
EPA1-CL4	3/22/95	NA	6.78	0.1	<0.1	<0.5	8.7	0.59	7.68	0.58	0.52	10.1	<0.5	NA	<1.0	<1.0	<1.0	<1.0	2.5	<1.0	<1.0	55.6	43.6	102	
EPA1-CL4	4/3/95	NA	6.86	0.1	<0.1	<0.5	8.3	<0.05	<0.05	<0.05	1.12	0.58	9.7	<0.5	NA	<1.0	<1.0	<1.0	1.0	<1.0	1.0	59.6	40.0	103	
EPA1-CL4	4/17/95	NA	6.91	<0.1	<0.1	<0.5	8.2	<0.05	0.37	1.20	0.65	10.4	10.4	NA	<1.0	<1.0	<1.0	7.5	1.4	<1.0	1.3	12.6	5.4	28	
EPA1-CL4	4/28/95	NA	6.93	0.1	<0.1	<0.5	9.5	0.33	1.52	0.85	0.61	10.3	<0.5	NA	<1.0	<1.0	<1.0	1.1	1.0	<1.0	1.0	8.1	6.7	18	
EPA1-CL4	5/12/95	NA	6.80	<0.1	0.4	<0.5	12.0	0.66	<0.05	<0.05	1.01	1.01	7.0	<0.5	NA	<1.0	<1.0	1.3	1.0	<1.0	1.0	5.1	4.2	13	
EPA1-CL4	4/21/96	NA	6.70	0.1	<0.1	<0.5	4.2	0.50	0.50	0.50	2.07	1.22	<0.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
EPA1-CL5	3/30/94	NA	5.90	0.2	8.9	1.0	2.9	<0.05	<0.05	<0.05	2.79	0.72	<0.5	NA	125.0	32.8	42.5	509.0	427.0	13.6	73.8	419.0	29.5	1672	
EPA1-CL5	4/7/94	NA	6.24	0.2	6.8	2.9	2.5	<0.05	<0.05	<0.05	2.48	0.74	5.8	NA	81.6	9.7	23.7	344.0	400.0	4.3	96.0	472.0	29.7	1461	
EPA1-CL5	4/11/94	NA	6.29	0.1	1.4	<0.5	1.6	<0.05	<0.05	<0.05	1.34	1.11	1.8	NA	2.4	34.4	136.0	388.0	773.0	457.0	66.8	331.0	57.5	2246	
EPA1-CL5	4/14/94	NA	6.13	<0.1	1.4	<0.59	1.7	<0.05	<0.05	<0.05	1.61	1.23	4.5	NA	<1.0	50.2	504.0	848.0	1670.0	1030.0	160.0	465.0	218.0	4945	
EPA1-CL5	4/18/94	NA	6.42	<0.1	2.4	6.4	8.1	0.09	<0.05	<0.05	3.25	1.17	16.7	NA	<1.0	50.0	225.0	404.0	767.0	451.0	195.0	533.0	155.0	2780	
EPA1-CL5	4/21/94	NA	6.11	<0.1	2.4	20.2	9.1	1.51	<0.05	<0.05	3.89	0.90	17.2	NA	<1.0	35.6	164.0	286.0	480.0	373.0	173.0	408.0	116.0	2030	
EPA1-CL5	4/25/94	NA	6.34	<0.1	2.4	35.2	10.7	3.18	0.18	0.44	0.44	20.5	20.5	NA	<1.0	14.8	109.0	169.0	203.0	218.0	63.4	204.0	65.4	1047	
EPA1-CL5	5/2/94	NA	6.14	0.1	2.0	48.1	8.5	<0.05	<0.05	<0.05	5.22	0.47	13.5	NA	<1.0	10.6	50.3	81.2	15.7	117.0	3.4	50.9	27.4	357	
EPA1-CL5	5/16/94	NA	6.15	<0.1	2.0	10.8	8.8	<0.05	<0.05	<0.05	4.99	0.89	9.1	NA	<1.0	<1.0	31.0	61.1	48.9	26.0	6.3	33.0	7.9	214	
EPA1-CL5	5/31/94	NA	6.21	0.1	1.3	1.4	9.2	0.14	<0.05	<0.05	2.34	0.71	6.6	NA	<1.0	<1.0	<1.0	21.7	118.0	28.2	3.3	51.7	5.4	228	
EPA1-CL5	6/13/94	NA	5.93	0.1	2.4	2.2	6.7	<0.05	<0.05	<0.05	0.98	0.80	2.6	NA	<1.0	5.7	277.0	488.0	920.0	818.0	65.5	285.0	101.0	2960	
EPA1-CL5	6/27/94	NA	6.21	0.1	1.4	10.8	1.2	3.51	<0.05	<0.05	0.56	0.59	NA	NA	<1.0	3.6	267.0	519.0	69.8	921.0	10.5	215.0	124.0	2130	
EPA1-CL5	7/11/94	NA	5.85	<0.1	1.5	10.4	9.7	<0.05	<0.05	<0.05	0.34	0.76	1.5	NA	<1.0	3.1	344.0	594.0	402.0	1050.0	58.8	413.0	243.0	3108	
EPA1-CL5	7/25/94	NA	5.78	<0.1	1.3	1.5	8.3	3.88	<0.05	<0.05	0.45	0.80	12.2	NA	<1.0	<1.0	88.8	251.0	179.0	460.0	68.7	507.0	286.0	1841	
EPA1-CL5	8/8/94	NA	6.01	<0.1	1.2	2.2	8.9	<0.05	<0.05	<0.05	0.87	0.80	0.7	NA	<1.0	<1.0	9.9	25.5	31.6	10.4	11.9	63.0	45.9	198	
EPA1-CL5	8/23/94	NA	6.05	<0.1	3.7	1.9	15.1	<0.05	<0.05	<0.05	3.20	0.73	<0.5	NA	<1.0	<1.0	6.3	15.4	21.3	5.5	12.9	48.1	38.3	148	

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	SO ₃ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEXTMB (ug/L)	
EPA1-CL5	9/6/94	NA	6.17	<0.1	2.9	2.3	13.9	<0.05	<0.05	3.73	0.84	<0.5	NA	<1.0	1.0	8.0	19.7	17.6	7.2	4.7	33.4	31.0	123	
EPA1-CL5	9/19/94	NA	6.08	<0.1	3.0	1.8	11.7	0.08	<0.05	2.43	1.24	<0.5	NA	<1.0	4.2	15.6	42.8	34.1	4.2	8.7	57.1	39.3	206	
EPA1-CL5	10/3/94	NA	6.45	<0.1	1.5	<0.5	10.8	3.30	1.68	3.37	0.76	11.7	NA	<1.0	<1.0	2.4	11.7	5.4	1.0	18.0	35.6	45.6	120	
EPA1-CL5	10/17/94	NA	6.50	<0.1	1.2	<0.5	9.7	1.03	1.12	0.71	0.71	11.5	NA	<1.0	<1.0	1.7	9.1	3.2	1.0	18.5	25.3	35.0	94	
EPA1-CL5	10/31/94	NA	6.55	<0.1	<0.1	<0.5	9.1	0.15	0.34	0.19	0.36	11.7	NA	<1.0	<1.0	1.5	15.0	2.5	1.6	16.2	59.4	43.0	139	
EPA1-CL5	11/11/94	NA	6.68	0.1	<0.1	0.9	8.9	1.25	2.31	0.51	0.37	9.9	NA	<1.0	<1.0	1.3	9.1	2.7	1.3	16.4	37.4	24.3	93	
EPA1-CL5	11/30/94	NA	6.71	<0.1	<0.1	<0.5	9.1	7.73	2.27	0.07	0.36	11.6	NA	<1.0	<1.0	2.1	10.7	2.0	<1.0	1.1	40.4	31.7	89	
EPA1-CL5	12/12/94	NA	6.61	<0.1	0.3	1.1	8.4	0.26	<0.05	<0.05	0.75	10.5	NA	<1.0	<1.0	4.8	22.9	3.4	<1.0	1.3	51.3	30.1	114	
EPA1-CL5	12/29/94	NA	6.48	0.1	1.2	<0.5	9.1	0.32	0.14	0.74	1.14	12.5	NA	<1.0	1.8	13.9	43.9	18.3	<1.0	8.8	53.1	20.7	161	
EPA1-CL5	1/9/95	NA	6.81	0.1	0.1	0.8	8.8	0.75	1.68	0.72	0.38	8.8	NA	<1.0	<1.0	3.4	9.2	2.6	<1.0	2.3	27.5	10.8	56	
EPA1-CL5	1/25/95	NA	6.76	0.8	<0.1	<0.5	8.8	4.48	6.12	0.23	0.30	11.1	NA	<1.0	<1.0	6.2	31.2	9.3	<1.0	5.2	87.0	44.1	183	
EPA1-CL5	2/6/95	NA	6.89	<0.1	<0.1	<0.5	8.2	0.57	3.66	0.26	0.27	10.8	NA	<1.0	<1.0	3.9	18.8	6.0	1.0	4.9	82.8	38.3	156	
EPA1-CL5	2/21/95	NA	6.88	0.2	<0.1	<0.5	8.4	8.07	8.55	<0.05	0.41	10.2	<0.5	<1.0	<1.0	<1.0	3.6	1.8	<1.0	1.6	17.9	22.7	48	
EPA1-CL5	3/6/95	NA	7.00	0.2	<0.1	<0.5	10.3	12.50	0.09	0.08	0.43	12.2	NA	<1.0	<1.0	<1.0	1.4	<1.0	<1.0	<1.0	<1.0	29.7	18.1	52
EPA1-CL5	3/22/95	NA	6.78	0.2	<0.1	<0.5	8.5	5.69	9.71	<0.05	0.50	9.8	<0.5	<1.0	<1.0	<1.0	2.4	<1.0	<1.0	1.1	28.0	21.5	54	
EPA1-CL5	4/3/95	NA	6.89	0.1	<0.1	<0.5	10.0	1.20	11.40	0.50	0.56	8.5	<0.5	<1.0	<1.0	6.6	33.9	5.4	<1.0	15.1	68.0	3.6	133	
EPA1-CL5	4/17/95	NA	6.73	<0.1	<0.1	<0.5	8.8	0.18	<0.05	1.31	0.67	3.1	<0.5	<1.0	<1.0	3.7	4.9	1.8	<1.0	1.9	9.7	5.0	25	
EPA1-CL5	4/28/95	NA	6.74	0.1	2.1	<0.5	10.0	<0.05	<0.05	1.13	0.90	5.6	<0.5	<1.0	<1.0	1.2	9.6	3.2	<1.0	3.0	30.1	16.5	66	
EPA1-CL5	5/12/95	NA	6.78	<0.1	2.0	<0.5	12.0	0.20	<0.05	1.25	1.02	<0.5	<0.5	<1.0	1.2	1.6	4.0	6.0	2.9	1.7	44.0	27.4	89	
EPA1-CL5	4/21/96	NA	6.85	<0.1	<0.1	<0.5	1.9	0.50	0.50	0.52	1.15	<0.5	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA2-CL1	3/30/94	NA	6.00	0.1	4.3	<0.5	3.4	<0.05	<0.05	0.21	<0.05	1.4	NA	<1.0	2.8	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3
EPA2-CL1	4/7/94	NA	6.56	0.1	4.5	<0.5	2.0	0.85	0.13	0.47	<0.05	47.8	NA	<1.0	2.9	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3
EPA2-CL1	4/11/94	NA	6.32	<0.1	4.5	<0.5	67.6	1.20	0.07	1.89	<0.05	96.6	NA	<1.0	<1.0	<1.0	<1.0	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1
EPA2-CL1	4/14/94	NA	6.15	0.1	5.1	<0.5	84.8	0.47	0.10	1.22	<0.05	67.6	NA	<1.0	<1.0	<1.0	<1.0	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2
EPA2-CL1	4/18/94	NA	6.14	0.1	2.2	<0.5	82.2	0.19	<0.05	0.66	<0.05	42.6	NA	<1.0	1.5	<1.0	<1.0	1.2	<1.0	<1.0	<1.0	<1.0	<1.0	3
EPA2-CL1	4/21/94	NA	6.33	0.1	2.2	<0.5	80.7	0.07	<0.05	0.41	<0.05	39.3	NA	<1.0	<1.0	<1.0	<1.0	1.2	<1.0	<1.0	<1.0	<1.0	<1.0	1
EPA2-CL1	4/25/94	NA	6.24	0.1	1.7	<0.5	99.3	<0.05	<0.05	0.32	<0.05	33.0	NA	<1.0	<1.0	<1.0	<1.0	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1
EPA2-CL1	5/2/94	NA	6.51	<0.1	0.9	<0.5	26.3	<0.05	<0.05	<0.05	<0.05	29.6	NA	<1.0	<1.0	<1.0	<1.0	1.4	2.5	<1.0	1.6	2.1	1.3	9
EPA2-CL1	5/16/94	NA	6.93	<0.1	0.4	<0.5	11.6	<0.05	<0.05	0.26	0.08	22.8	NA	<1.0	<1.0	<1.0	<1.0	1.3	2.1	<1.0	1.7	1.9	1.0	8
EPA2-CL1	5/31/94	NA	6.76	0.1	1.0	0.5	9.7	0.19	<0.05	0.07	0.09	21.6	NA	<1.0	<1.0	<1.0	<1.0	1.4	2.2	<1.0	2.2	2.4	1.5	10
EPA2-CL1	6/13/94	NA	6.50	<0.1	0.9	0.8	8.8	<0.05	<0.05	0.30	0.09	9.9	NA	<1.0	<1.0	<1.0	<1.0	1.8	3.1	<1.0	2.3	3.2	2.1	13
EPA2-CL1	6/27/94	NA	6.18	0.2	0.8	<0.5	63.2	<0.05	<0.05	0.78	<0.05	1.6	NA	<1.0	<1.0	<1.0	<1.0	1.6	2.9	<1.0	1.9	3.0	2.0	11
EPA2-CL1	7/11/94	NA	6.54	<0.1	0.4	<0.5	5.0	<0.05	<0.05	0.63	<0.05	<0.5	NA	<1.0	<1.0	<1.0	<1.0	1.3	<1.0	1.7	2.0	1.3	6	
EPA2-CL1	7/11/94	NA	6.54	<0.1	0.9	<0.5	1.7	<0.05	<0.05	0.62	<0.05	<0.5	NA	<1.0	<1.0	<1.0	<1.0	1.3	<1.0	2.3	2.2	1.4	7	
EPA2-CL1	7/25/94	NA	6.21	0.1	0.4	<0.5	8.7	<0.05	<0.05	0.35	<0.05	2.7	NA	<1.0	<1.0	<1.0	<1.0	1.2	1.6	<1.0	2.4	2.5	1.8	10
EPA2-CL1	7/25/94	NA	6.28	<0.1	0.3	0.8	8.7	<0.05	<0.05	0.35	<0.05	<0.5	NA	<1.0	<1.0	<1.0	<1.0	1.5	2.0	<1.0	2.9	2.8	2.5	13
EPA2-CL1	8/8/94	NA	6.16	0.2	2.6	<0.5	10.0	<0.05	<0.05	0.47	<0.05	<0.5	NA	<1.0	<1.0	<1.0	<1.0	1.5	2.0	1.0	2.9	2.8	2.5	14
EPA2-CL1	8/23/94	NA	6.10	0.3	1.3	0.7	11.1	<0.05	<0.05	0.88	<0.05	2.4	NA	<1.0	<1.0	<1.0	<1.0	1.7	2.1	1.0	3.0	2.6	2.2	14
EPA2-CL1	9/6/94	NA	6.49	<0.1	0.5	<0.5	10.8	0.07	<0.05	0.85	0.06	12.1	NA	<1.0	<1.0	<1.0	<1.0	1.0	1.0	1.5	2.1	1.8	8	
EPA2-CL1	9/19/94	NA	6.49	<0.1	0.5	<0.5	13.5	0.08	<0.05	0.52	<0.05	11.3	NA	<1.0	<1.0	<1.0	<1.0	1.0	1.0	1.5	2.1	1.8	8	
EPA2-CL1	10/3/94	NA	6.50	0.2	0.9	<0.5	8.8	0.09	<0.05	0.37	<0.05	8.7	NA	<1.0	<1.0	<1.0	<1.0	1.1	1.3	1.0	1.7	2.5	1.7	10
EPA2-CL1	10/17/94	NA	6.49	<0.1	0.6	<0.5	9.5	0.14	<0.05	0.17	<0.05	8.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.1	2.3	2.0	7
EPA2-CL1	10/31/94	NA	6.68	0.1	0.4	<0.5	9.5	0.16	<0.05	0.28	<0.05	11.0	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.6	1.5		

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S ₂ O ₃ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEXTMB (ug/L)	
EPA2-CL1	4/17/95	NA	6.89	0.1	<0.1	<0.5	9.4	<0.05	<0.05	<0.05	<0.05	<0.05	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1
EPA2-CL1	4/28/95	NA	6.89	0.1	<0.1	<0.5	7.5	<0.05	<0.05	0.20	<0.05	8.5	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA2-CL1	5/12/95	NA	6.94	0.2	<0.1	<0.5	9.3	<0.05	<0.05	0.14	<0.05	7.9	0.7	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA2-CL1	4/21/96	NA	6.39	0.5	<0.1	<0.5	2.5	0.50	0.50	0.27	<0.05	6.2	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA2-CL2	3/30/94	NA	5.50	0.2	4.0	<0.5	4.9	<0.05	<0.05	0.19	<0.05	<0.5	NA	<1.0	10.7	2.5	4.4	7.2	5.2	107.0	36.7	26.4	200	200
EPA2-CL2	4/7/94	NA	5.67	0.2	3.6	2.0	3.8	<0.05	<0.05	0.18	<0.05	<0.5	NA	<1.0	9.8	2.3	3.0	4.4	4.3	93.1	32.8	25.3	175	175
EPA2-CL2	4/11/94	NA	5.60	<0.1	3.3	1.5	3.1	0.30	<0.05	0.80	<0.05	<0.5	NA	<1.0	9.6	1.7	3.2	4.9	3.8	106.0	37.5	77.3	244	244
EPA2-CL2	4/14/94	NA	5.53	<0.7	11.6	<0.5	53.9	0.36	0.13	2.23	<0.05	84.6	NA	<1.0	9.0	1.4	2.6	3.9	3.4	94.5	30.5	24.1	169	169
EPA2-CL2	4/18/94	NA	5.88	<0.1	6.2	<0.5	66.1	<0.05	<0.05	1.42	<0.05	69.6	NA	<1.0	10.1	1.5	2.7	4.3	3.3	96.4	30.8	23.6	173	173
EPA2-CL2	4/21/94	NA	6.01	0.1	3.9	<0.5	75.3	<0.05	<0.05	0.99	<0.05	45.2	NA	<1.0	9.0	1.2	2.5	3.9	3.2	97.8	30.6	24.3	173	173
EPA2-CL2	4/25/94	NA	6.13	<0.1	2.8	<0.5	88.8	<0.05	<0.05	0.74	<0.05	50.3	NA	<1.0	8.5	1.1	2.5	3.8	3.2	94.7	30.1	23.7	168	168
EPA2-CL2	5/2/94	NA	6.24	0.2	1.7	1.0	92.1	<0.05	<0.05	0.41	<0.05	40.8	NA	<1.0	6.3	1.1	2.6	3.9	2.8	79.9	27.7	21.7	146	146
EPA2-CL2	5/16/94	NA	6.68	0.1	0.6	<0.5	12.0	<0.05	<0.05	0.26	0.13	25.8	NA	<1.0	2.2	1.0	2.3	3.1	2.1	75.5	24.7	20.6	132	132
EPA2-CL2	5/31/94	NA	6.73	0.2	1.1	1.0	13.7	0.12	<0.05	0.93	0.09	19.6	NA	<1.0	<1.0	<1.0	2.1	2.9	1.9	77.0	21.9	19.6	125	125
EPA2-CL2	6/13/94	NA	6.58	<0.1	0.9	<0.5	7.0	<0.05	<0.05	0.94	0.08	12.3	NA	<1.0	<1.0	<1.0	2.3	2.9	1.9	74.2	22.2	20.3	124	124
EPA2-CL2	6/27/94	NA	6.11	0.1	1.1	<0.5	68.2	<0.05	<0.05	1.79	<0.05	6.6	NA	<1.0	<1.0	<1.0	2.2	3.0	2.6	71.3	22.9	18.2	120	120
EPA2-CL2	7/11/94	NA	6.57	<0.1	0.1	<0.5	7.4	0.15	<0.05	0.92	<0.05	<0.5	NA	<1.0	<1.0	<1.0	1.2	1.1	<1.0	76.4	19.3	17.8	116	116
EPA2-CL2	7/25/94	NA	6.06	0.1	0.3	<0.5	1.3	<0.05	<0.05	0.57	<0.05	<0.5	NA	<1.0	<1.0	<1.0	1.1	1.0	<1.0	70.7	20.0	17.7	111	111
EPA2-CL2	8/8/94	NA	6.02	<0.1	0.1	1.1	10.1	<0.05	<0.05	0.49	<0.05	<0.5	NA	<1.0	<1.0	<1.0	1.2	1.1	<1.0	66.5	17.5	17.3	104	104
EPA2-CL2	8/23/94	NA	6.14	0.1	1.4	<0.5	8.7	<0.05	<0.05	0.87	<0.05	<0.5	NA	<1.0	<1.0	<1.0	1.0	1.0	<1.0	75.2	15.6	77.5	171	171
EPA2-CL2	9/6/94	NA	6.02	0.1	0.4	1.4	9.8	<0.05	<0.05	2.03	<0.05	<0.5	NA	<1.0	<1.0	<1.0	1.0	1.2	<1.0	73.3	14.2	12.5	103	103
EPA2-CL2	9/19/94	NA	6.45	<0.1	0.2	<0.5	11.2	0.07	<0.05	1.55	<0.05	7.4	NA	<1.0	<1.0	<1.0	1.0	1.0	<1.0	79.2	15.5	91.7	188	188
EPA2-CL2	10/3/94	NA	6.37	0.1	0.6	<0.5	10.0	0.08	<0.05	0.43	<0.05	7.9	NA	<1.0	<1.0	<1.0	1.0	1.0	<1.0	71.8	12.9	15.3	102	102
EPA2-CL2	10/17/94	NA	6.49	<0.1	0.4	<0.5	9.6	0.09	<0.05	0.40	<0.05	8.8	NA	<1.0	<1.0	<1.0	1.4	1.0	<1.0	71.4	12.5	16.2	100	100
EPA2-CL2	10/31/94	NA	6.59	<0.1	0.2	<0.5	9.5	0.09	<0.05	0.18	<0.05	6.1	NA	<1.0	<1.0	<1.0	1.0	1.0	<1.0	69.7	13.0	14.4	97	97
EPA2-CL2	11/11/94	NA	6.68	<0.1	0.1	1.0	8.1	0.13	<0.05	0.41	<0.05	6.8	NA	<1.0	<1.0	<1.0	1.0	1.0	<1.0	55.0	9.2	10.7	75	75
EPA2-CL2	11/30/94	NA	6.88	<0.1	0.1	<0.5	10.0	<0.05	<0.05	0.07	<0.05	4.9	NA	<1.0	<1.0	<1.0	1.0	1.0	<1.0	59.6	9.4	10.6	80	80
EPA2-CL2	12/12/94	NA	6.92	<0.1	0.3	0.9	9.1	<0.05	<0.05	<0.05	<0.05	3.4	NA	<1.0	<1.0	<1.0	1.0	1.0	<1.0	58.2	9.2	10.6	78	78
EPA2-CL2	12/29/94	NA	6.68	0.2	0.1	<0.5	9.3	0.06	<0.05	<0.05	<0.05	8.9	NA	<1.0	<1.0	<1.0	1.0	1.0	<1.0	55.9	7.7	9.9	74	74
EPA2-CL2	1/9/95	NA	7.01	0.1	<0.1	<0.5	7.3	<0.05	<0.05	<0.05	<0.05	4.0	NA	<1.0	<1.0	<1.0	1.0	1.0	<1.0	54.2	7.8	9.5	72	72
EPA2-CL2	1/25/95	NA	7.05	0.2	<0.1	<0.5	8.1	<0.05	<0.05	<0.05	<0.05	5.2	NA	<1.0	<1.0	<1.0	1.0	1.0	<1.0	55.5	7.8	9.5	73	73
EPA2-CL2	2/6/95	NA	7.14	NA	<0.1	<0.5	8.8	<0.05	<0.05	<0.05	<0.05	7.9	NA	<1.0	<1.0	<1.0	1.0	1.0	<1.0	51.6	6.7	9.0	67	67
EPA2-CL2	2/21/95	NA	7.02	0.2	<0.1	<0.5	8.4	<0.05	<0.05	<0.05	<0.05	3.8	2.4	<1.0	<1.0	<1.0	1.0	1.0	<1.0	50.9	6.1	9.4	66	66
EPA2-CL2	3/6/95	NA	7.07	<0.1	<0.1	<0.5	10.2	<0.05	<0.05	<0.05	<0.05	11.8	NA	<1.0	<1.0	<1.0	1.0	1.0	<1.0	43.7	5.1	73.7	123	123
EPA2-CL2	3/22/95	NA	6.96	0.2	<0.1	<0.5	7.5	0.09	<0.05	<0.05	<0.05	3.5	2.7	<1.0	<1.0	<1.0	1.0	1.0	<1.0	44.6	4.2	6.2	55	55
EPA2-CL2	4/3/95	NA	6.91	0.2	<0.1	<0.5	7.9	<0.05	<0.05	0.25	<0.05	3.1	2.4	<1.0	<1.0	<1.0	1.0	1.0	<1.0	44.2	4.3	6.2	55	55
EPA2-CL2	4/17/95	NA	6.95	0.1	<0.1	<0.5	8.4	<0.05	<0.05	<0.05	<0.05	1.4	1.8	<1.0	<1.0	<1.0	1.0	1.0	<1.0	38.1	3.6	6.0	48	48
EPA2-CL2	4/28/95	NA	7.00	<0.1	<0.1	<0.5	6.9	<0.05	<0.05	0.15	<0.05	1.0	1.6	<1.0	<1.0	<1.0	1.0	1.0	<1.0	32.4	6.2	8.0	94	94
EPA2-CL2	5/12/95	NA	6.93	<0.1	<0.1	<0.5	10.2	<0.05	<0.05	0.12	<0.05	1.5	2.7	<1.0	<1.0	<1.0	6.9	15.4	13.0	49.4	7.0	6.7	65	65
EPA2-CL2	4/21/96	NA	6.30	0.1	<0.1	<0.5	2.2	0.50	0.50	0.41	<0.05	<0.5	<0.5	<1.0	<1.0	<1.0	<1.0	1.3	1.0	49.4	7.0	6.7	65	65
EPA2-CL3	3/30/94	NA	5.70	0.1	7.7	<0.5	5.8	<0.05	<0.05	1.17	0.10	<0.5	NA	9.9	195.0	389.0	748.0	1770.0	96.2	247.0	765.0	320.0	4522	4522
EPA2-CL3	4/7/94	NA	6.00	0.2	6.8	3.3	11.3	<0.05	<0.05	1.59	0.24	<0.5	NA	7.8	214.0	293.0	579.0	1350.0	119.0	219.0	609.0	261.0	3652	3652
EPA2-CL3	4/11/94	NA	5.59	0.2	1.4	2.3	3.1	<0.05	<0.05	0.32	0.13	<0.5	NA	<1.0	71.1	47.2	97.8	200.0	76.8	179.0	272.0	114.0	1058	1058
EPA2-CL3	4/14/94	NA	5.38	<0.1	3.3	1.9	14.4	0.10	<0.05	0.75	0.07	3.4	NA	<1.0	56.0	29.2	57.4	115.0	64.8	181.0	163.0	73.7	740	740
EPA2-CL3	4/18/94	NA	5.33	<0.1	2.6	<0.5	88.1	0.32	0.19	1.07	<0.05	23.2	NA	<1.0	39.2	20.6	41.5	78.8	48.7	197.0	146.0	70.7	643	643
EPA2-CL3	4/18/94	NA	5.80	0.2	3.0	<0.5	79.4	1.84	0.32	0.52	<0.05	22.0	NA	<1.0	32.1	17.8	37.6	69.6	44.0	173.0	119.0	63.4	557	557
EPA2-CL3	4/25/94	NA	5.93	<0.1	1.4	<0.5	83.0	<0.05	<0.05	0.34	<0.05	14.9	NA	<1.0	23.6	14.5	32.7	64.0	39.7	178.0	127.0	63.8	543	543
EPA2-CL3	5/2/94	NA	5.62	<0.1	0.7	<0.5	96.6	<0.05	<0.05	0.17	<0.05	10.9	NA	<1.0	5.7	7.9	16.4	32.2	12.4	189.0	133.0	66.0	463	463
EPA2-CL3	5/16/94	NA	6.13	<0.1	<0.1	<0.5	10.4	<0.05	<0.05	<0.05	0.09	1.7	NA	<1.0	1.7	4.9	10.5	20.8	8.2	202.0	148.0	79.0	475	475
EPA2-CL3	5/31/94	NA	6.35	<0.1	1.5	<0.52	11.4	0.11	<0.05	0.39	0.07	7.8	NA	<1.0	<1.0	2.0	5.1	9.4	3.8	235.0	205.0	117.0	577	577
EPA2-CL3	6/13/94	NA	6.41	<0.1	0.2	<0.5	9.6	<0.05	<0.05	0.81	0.07	15.2	NA	<1.0	<1.0	1.7	4.9	8.2	3.5	193.0	135.0	69.6	416	416

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	SO ₂ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PAYL (ug/L)	MAXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSQU (ug/L)	TMB (ug/L)	BTEXTMB (ug/L)
EPA2-CL3	6/27/94	NA	5.81	<0.1	0.5	<0.5	76.6	<0.05	<0.05	0.86	<0.05	NA	NA	<1.0	<1.0	1.2	3.5	4.5	3.2	96.7	28.2	49.9	207
EPA2-CL3	7/1/94	NA	6.07	<0.1	0.1	<0.5	13.8	3.59	0.19	0.24	<0.05	11.6	NA	<1.0	<1.0	1.2	3.5	4.6	4.3	78.4	65.2	49.9	207
EPA2-CL3	7/25/94	NA	5.93	<0.1	<0.1	<0.5	2.1	<0.05	<0.05	0.35	<0.05	<0.5	NA	<1.0	<1.0	<1.0	1.7	2.4	7.4	76.4	47.7	31.0	161
EPA2-CL3	8/8/94	NA	5.90	<0.1	0.1	1.6	7.3	<0.05	<0.05	0.14	<0.05	4.3	NA	<1.0	<1.0	3.5	6.6	7.5	12.5	50.8	29.7	26.9	138
EPA2-CL3	8/23/94	NA	6.15	<0.1	2.2	<0.5	5.4	<0.05	<0.05	0.49	<0.05	0.7	NA	<1.0	<1.0	6.7	11.5	23.3	17.6	139.0	69.1	48.0	315
EPA2-CL3	9/6/94	NA	6.09	<0.1	1.9	1.4	10.0	<0.05	<0.05	1.46	<0.05	<0.5	NA	<1.0	<1.0	2.8	5.8	10.0	7.8	188.0	69.9	39.5	304
EPA2-CL3	9/19/94	NA	6.45	0.1	0.4	<0.5	10.6	0.07	<0.05	1.21	<0.05	5.9	NA	<1.0	<1.0	<1.0	1.1	<1.0	1.0	152.0	71.7	42.9	270
EPA2-CL3	10/3/94	NA	6.40	<0.1	<0.1	<0.5	10.4	0.08	<0.05	0.16	<0.05	7.3	NA	<1.0	<1.0	<1.0	1.0	<1.0	1.0	67.1	11.5	16.6	97
EPA2-CL3	10/17/94	NA	6.39	<0.1	0.3	<0.5	9.3	0.20	<0.05	0.36	<0.05	11.6	NA	<1.0	<1.0	<1.0	1.7	1.0	1.7	174.0	59.8	38.5	277
EPA2-CL3	10/31/94	NA	6.57	<0.1	<0.1	<0.5	9.1	0.08	<0.05	<0.05	<0.05	4.6	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	119.0	25.5	21.7	166
EPA2-CL3	11/1/94	NA	6.84	<0.1	<0.1	0.9	8.9	<0.05	<0.05	0.37	<0.05	5.6	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	119.0	40.7	27.1	187
EPA2-CL3	11/30/94	NA	6.89	<0.1	<0.1	<0.5	10.0	<0.05	<0.05	0.05	<0.05	0.8	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	153.0	57.6	36.3	247
EPA2-CL3	12/12/94	NA	6.95	0.1	<0.1	1.0	8.1	<0.05	<0.05	<0.05	<0.05	3.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	170.0	74.9	40.1	285
EPA2-CL3	12/29/94	NA	6.80	0.1	0.1	<0.5	9.1	0.06	<0.05	<0.05	<0.05	0.6	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	149.0	58.7	32.2	240
EPA2-CL3	1/9/95	NA	7.02	0.1	<0.1	<0.5	9.2	<0.05	<0.05	<0.05	<0.05	5.3	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	105.0	26.2	17.7	149
EPA2-CL3	1/25/95	NA	6.98	0.2	<0.1	<0.5	8.3	<0.05	<0.05	<0.05	<0.05	6.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	82.6	14.2	75.0	172
EPA2-CL3	2/6/95	NA	7.16	NA	<0.1	<0.5	8.0	<0.05	<0.05	<0.05	<0.05	0.7	3.2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	158.0	68.3	39.4	266
EPA2-CL3	2/21/95	NA	7.08	0.3	<0.1	<0.5	7.6	<0.05	<0.05	<0.05	<0.05	3.3	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	137.0	36.1	30.1	204
EPA2-CL3	3/6/95	NA	7.07	<0.1	<0.1	<0.5	10.2	<0.05	<0.05	<0.05	<0.05	1.0	3.3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	121.0	28.4	25.7	173
EPA2-CL3	3/22/95	NA	6.92	0.2	<0.1	1.0	7.5	0.08	<0.05	<0.05	<0.05	1.1	4.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	104.0	16.4	11.4	132
EPA2-CL3	4/3/95	NA	6.99	0.1	<0.1	<0.5	8.5	<0.05	<0.05	0.20	<0.05	1.1	3.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	117.0	30.8	18.7	167
EPA2-CL3	4/17/95	NA	7.04	0.1	<0.1	<0.5	8.1	<0.05	<0.05	0.16	<0.05	0.5	1.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	38.7	3.6	6.3	49
EPA2-CL3	4/28/95	NA	7.05	<0.1	<0.1	<0.5	4.8	<0.05	<0.05	0.37	<0.05	0.7	3.5	<1.0	13.9	10.2	9.4	22.8	18.5	37.9	5.5	9.9	128
EPA2-CL3	5/12/95	NA	7.00	<0.1	<0.1	<0.5	10.8	<0.05	<0.05	0.37	<0.05	0.7	3.5	<1.0	13.9	10.2	9.4	22.8	18.5	37.9	5.5	9.9	128
EPA2-CL3	4/21/96	NA	6.09	<0.1	<0.1	<0.5	20.2	0.50	0.50	0.22	0.23	<0.5	<0.5	<1.0	1.5	<1.0	12.7	25.1	<1.0	138.0	76.8	87.4	346
EPA2-CL4	3/30/94	NA	5.90	0.1	1.5	<0.5	5.0	<0.05	<0.05	0.38	<0.05	<0.5	NA	39.1	2970.0	709.0	1130.0	2560.0	1740.0	237.0	880.0	217.0	10482
EPA2-CL4	4/7/94	NA	6.34	0.1	2.0	2.2	2.9	<0.05	<0.05	1.72	<0.05	<0.5	NA	54.8	2600.0	725.0	1540.0	3750.0	2690.0	397.0	1440.0	462.0	13659
EPA2-CL4	4/11/94	NA	6.02	<0.1	2.0	2.6	4.3	<0.05	<0.05	0.93	<0.05	<0.5	NA	19.7	332.0	286.0	654.0	1500.0	334.0	258.0	853.0	289.0	4526
EPA2-CL4	4/14/94	NA	5.68	<0.1	3.1	1.3	8.2	<0.05	<0.05	1.18	0.06	11.0	NA	5.2	181.0	305.0	707.0	1530.0	131.0	238.0	750.0	355.0	4202
EPA2-CL4	4/18/94	NA	5.62	0.1	2.7	1.8	1.2	<0.05	<0.05	0.52	0.13	1.9	NA	<1.0	53.9	55.2	117.0	238.0	92.7	206.0	409.0	164.0	1336
EPA2-CL4	4/21/94	NA	5.60	<0.1	6.0	<0.5	30.6	<0.05	<0.05	1.08	<0.05	2.5	NA	<1.0	34.1	36.3	69.0	137.0	63.6	173.0	231.0	93.6	838
EPA2-CL4	4/25/94	NA	5.37	<0.1	2.5	<0.5	85.4	<0.05	<0.05	1.31	<0.05	<0.5	NA	<1.0	26.7	32.0	61.4	124.0	59.4	185.0	175.0	77.2	741
EPA2-CL4	5/2/94	NA	5.45	<0.1	6.5	<0.5	84.1	<0.05	<0.05	0.67	0.06	13.8	NA	<1.0	16.3	20.9	39.5	79.1	36.9	200.0	217.0	119.0	675
EPA2-CL4	5/16/94	NA	6.00	<0.1	0.2	<0.5	12.5	<0.05	<0.05	<0.05	0.13	10.3	NA	<1.0	5.8	14.7	28.9	53.1	36.9	200.0	217.0	119.0	675
EPA2-CL4	5/31/94	NA	6.54	0.1	1.1	0.8	13.5	0.12	<0.05	0.40	0.09	5.9	NA	<1.0	2.5	17.2	32.2	53.9	30.4	177.0	152.0	126.0	591
EPA2-CL4	6/13/94	NA	6.43	<0.1	0.3	<0.5	9.3	<0.05	<0.05	0.76	0.10	6.9	NA	<1.0	<1.0	3.3	8.6	12.2	5.7	242.0	208.0	115.0	595
EPA2-CL4	6/27/94	NA	6.33	<0.1	0.5	<0.5	92.2	<0.05	<0.05	0.38	<0.05	NA	NA	<1.0	104.0	27.0	40.1	77.8	79.4	86.3	47.0	38.2	501
EPA2-CL4	7/1/94	NA	6.04	0.1	<0.1	<0.5	43.4	<0.05	<0.05	0.30	<0.05	2.6	NA	<1.0	<1.0	3.0	58.8	98.9	38.8	83.9	216.0	110.0	638
EPA2-CL4	7/15/94	NA	5.80	<0.1	<0.1	0.6	2.8	<0.05	<0.05	0.11	0.12	<0.5	NA	<1.0	<1.0	6.3	16.6	22.5	18.7	40.3	53.2	38.8	196
EPA2-CL4	7/25/94	NA	5.68	<0.1	0.3	1.8	9.6	<0.05	<0.05	0.11	<0.05	3.9	NA	<1.0	<1.0	1.6	5.9	4.9	6.3	64.5	36.5	37.3	157
EPA2-CL4	8/8/94	NA	6.08	<0.1	5.1	<0.5	7.8	<0.05	<0.05	0.52	<0.05	<0.5	NA	<1.0	<1.0	1.6	6.0	5.7	7.8	49.3	19.4	23.5	113
EPA2-CL4	8/23/94	NA	6.15	<0.1	1.3	1.4	10.3	<0.05	<0.05	0.43	0.07	<0.5	NA	<1.0	<1.0	4.0	11.5	19.3	37.3	109.0	87.3	98.7	367
EPA2-CL4	9/6/94	NA	6.27	<0.1	0.5	0.8	8.9	0.08	<0.05	1.67	0.07	1.3	NA	<1.0	<1.0	<1.0	1.0	1.0	1.0	93.6	43.7	33.1	173
EPA2-CL4	9/19/94	NA	6.38	<0.1	0.4	<0.5	12.0	0.10	<0.05	0.23	<0.05	9.5	NA	<1.0	<1.0	<1.0	1.2	1.3	1.7	200.0	90.1	61.1	355
EPA2-CL4	10/1/94	NA	6.41	<0.1	1.0	0.8	7.3	0.08	<0.05	0.24	<0.05	0.7	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	200.0	87.6	54.1	342
EPA2-CL4	10/31/94	NA	6.57	<0.1	0.5	<0.5	9.5	<0.05	<0.05	<0.05	<0.05	10.6	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	116.0	37.6	26.0	180
EPA2-CL4	11/1/94	NA	6.65	<0.1	0.5	0.8	9.7	<0.05	<0.05	0.24	<0.05	6.6	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	161.0	49.1	40.5	251
EPA2-CL4	11/30/94	NA	6.89	<0.1	0.1	<0.5	9.1	<0.05	<0.05	<0.05	<0.05	4.9	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	230.0	144.0	80.2	454
EPA2-CL4	12/12/94	NA	7.01	<0.1	<0.1	0.9	7.5	<0.05	<0.05	<0.05	<0.05	11.0	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	231.0	120.0	88.8	440
EPA2-CL4	12/29/94	NA	6.87	0.1	<0.1	<0.5	9.2	<0.05	<0.05	<0.05	<0.05	2.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	214.0	108.0	85.7	408
EPA2-CL4	1/9/95	NA	7.04	0.1	<0.1	<0.5	9.2	<0.05	<0.05	<0.05	<0.05	0.8	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	150.0	49.6	39.6	242
EPA2-CL4	1/25/95	NA	6.93	0.1	<0.1	<0.5	8.8	<0.05	<0.05	<0.05	<0.05	1.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	13.0	150.0	49.6	39.6

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S _O ₃ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEX/TMB (ug/L)	
EPA2-CL4	2/6/95	NA	7.15	NA	<0.1	<0.5	7.7	<0.05	<0.05	<0.05	<0.05	4.2	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	52.8	7.6	82.9	143
EPA2-CL4	2/21/95	NA	7.08	0.3	<0.1	<0.5	8.6	<0.05	<0.05	<0.05	<0.05	0.6	3.9	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	163.0	48.5	41.0	253
EPA2-CL4	3/6/95	NA	7.09	0.1	<0.1	<0.5	10.1	<0.05	<0.05	<0.05	<0.05	2.9	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	163.0	38.0	46.4	247
EPA2-CL4	3/22/95	NA	6.90	0.1	<0.1	<0.5	9.1	0.07	<0.05	<0.05	<0.05	1.0	3.9	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	160.0	57.3	64.0	282
EPA2-CL4	4/3/95	NA	7.01	0.1	<0.1	<0.5	9.1	<0.05	<0.05	0.22	<0.05	1.1	4.4	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	212.0	92.0	54.7	359
EPA2-CL4	4/17/95	NA	7.05	<0.1	<0.1	<0.5	8.1	<0.05	<0.05	<0.05	<0.05	1.2	2.8	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	152.0	47.4	26.3	226
EPA2-CL4	4/28/95	NA	7.02	<0.1	<0.1	<0.5	8.8	<0.05	<0.05	0.12	<0.05	1.4	3.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	17.8	3.9	10.9	33
EPA2-CL4	5/12/95	NA	7.02	<0.1	<0.1	<0.5	10.3	<0.05	<0.05	0.23	<0.05	0.8	3.6	<1.0	<1.0	8.2	8.0	19.0	1.1	48.1	9.4	7.5	101	
EPA2-CL4	4/21/96	NA	6.06	<0.1	<0.1	<0.5	27.0	0.50	0.50	0.21	<0.05	<0.5	<0.5	1.2	7.2	74.0	184.0	296.0	4.7	18.4	408.0	234.0	1228	
EPA2-CL5	3/30/94	NA	5.80	0.4	2.3	0.7	4.4	<0.05	<0.05	0.38	<0.05	<0.5	NA	20.0	1700.0	249.0	724.0	1930.0	569.0	39.0	143.0	98.7	5473	
EPA2-CL5	4/7/94	NA	6.13	0.2	1.6	2.1	3.2	<0.05	<0.05	0.29	<0.05	0.6	NA	5.9	313.0	88.1	443.0	1150.0	113.0	93.1	256.0	130.0	2592	
EPA2-CL5	4/11/94	NA	5.93	<0.1	1.0	1.7	4.3	<0.05	<0.05	0.30	<0.05	<0.5	NA	18.7	1280.0	372.0	671.0	1500.0	886.0	158.0	568.0	172.0	5626	
EPA2-CL5	4/14/94	NA	5.87	<0.1	1.5	2.0	4.0	<0.05	<0.05	0.91	<0.05	<0.5	NA	48.3	3390.0	1060.0	2000.0	4220.0	3160.0	393.0	1390.0	480.0	16141	
EPA2-CL5	4/18/94	NA	6.03	0.1	2.2	2.1	6.0	<0.05	<0.05	1.42	<0.05	0.8	NA	17.5	298.0	359.0	755.0	1570.0	319.0	329.0	923.0	330.0	4901	
EPA2-CL5	4/21/94	NA	6.10	<0.1	1.5	1.1	4.9	<0.05	<0.05	0.84	<0.05	4.0	NA	3.3	78.8	283.0	650.0	101.0	257.0	829.0	397.0	3999		
EPA2-CL5	4/25/94	NA	6.01	<0.1	7.0	<0.5	7.6	<0.05	<0.05	0.79	<0.05	3.5	NA	<1.0	34.3	50.4	110.0	226.0	71.7	189.0	432.0	181.0	1294	
EPA2-CL5	5/2/94	NA	5.51	<0.1	2.1	<0.5	90.8	0.08	<0.05	1.58	<0.05	6.0	NA	<1.0	16.8	26.9	52.1	101.0	34.6	158.0	170.0	77.2	637	
EPA2-CL5	5/16/94	NA	5.91	<0.1	1.8	<0.5	89.8	<0.05	<0.05	0.19	<0.05	9.7	NA	<1.0	4.9	18.0	36.6	61.4	39.4	178.0	209.0	114.0	861	
EPA2-CL5	5/31/94	NA	6.49	0.1	1.5	0.6	9.6	0.13	<0.05	<0.05	0.07	10.9	NA	<1.0	<1.0	5.0	13.6	22.1	14.9	14.8	141.0	124.0	335	
EPA2-CL5	6/13/94	NA	6.71	<0.1	0.5	<0.5	13.0	<0.05	<0.05	0.34	0.07	3.8	NA	<1.0	<1.0	11.0	22.8	27.3	24.4	191.0	159.0	109.0	545	
EPA2-CL5	6/27/94	NA	5.83	0.1	1.4	<0.5	99.6	<0.05	<0.05	0.16	0.06	NA	NA	<1.0	<1.0	5.0	11.4	7.9	14.2	51.4	33.0	31.7	155	
EPA2-CL5	7/11/94	NA	6.30	<0.1	3.0	<0.5	76.6	<0.05	<0.05	0.32	<0.05	3.1	NA	<1.0	<1.0	13.7	29.0	33.4	21.4	125.0	210.0	89.3	2938	
EPA2-CL5	7/25/94	NA	6.34	<0.1	0.6	<0.59	8.9	<0.05	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	42.5	349.0	570.0	763.0	259.0	573.0	381.0	2938	
EPA2-CL5	8/6/94	NA	6.17	<0.1	0.2	1.3	11.1	<0.05	<0.05	0.16	0.11	0.6	NA	<1.0	<1.0	7.2	14.1	8.6	17.9	82.6	70.0	46.7	227	
EPA2-CL5	8/23/94	NA	6.12	<0.1	1.4	<0.5	6.7	<0.05	<0.05	0.21	0.07	<0.5	NA	<1.0	<1.0	6.5	16.1	24.6	26.9	94.3	72.8	66.8	308	
EPA2-CL5	9/6/94	NA	6.20	<0.1	0.5	2.3	10.0	<0.05	<0.05	0.60	0.07	<0.5	NA	<1.0	<1.0	125.0	526.0	1050.0	701.0	260.0	546.0	381.0	3589	
EPA2-CL5	9/19/94	NA	6.17	<0.1	0.7	1.3	11.1	0.08	<0.05	1.29	0.09	<0.5	NA	<1.0	<1.0	1.8	7.0	10.2	9.4	112.0	54.7	59.5	255	
EPA2-CL5	10/3/94	NA	6.30	<0.1	<0.1	<0.5	9.2	0.08	<0.05	0.69	0.10	2.1	NA	<1.0	<1.0	1.0	2.5	3.3	2.9	207.0	100.0	53.0	370	
EPA2-CL5	10/17/94	NA	6.31	<0.1	1.2	<0.5	11.2	0.07	<0.05	0.45	0.07	6.3	NA	<1.0	<1.0	1.4	5.5	2.9	3.2	52.9	36.0	23.9	126	
EPA2-CL5	10/31/94	NA	6.42	<0.1	1.0	<0.5	5.9	0.08	<0.05	0.11	0.07	<0.5	NA	<1.0	<1.0	1.0	1.8	1.5	1.6	80.3	32.2	33.3	152	
EPA2-CL5	11/11/94	NA	6.58	<0.1	0.7	0.8	9.4	<0.05	<0.05	0.18	0.08	3.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	143.0	56.1	38.0	237	
EPA2-CL5	11/30/94	NA	6.71	<0.1	0.7	<0.5	9.2	<0.05	<0.05	0.30	0.07	3.9	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	194.0	104.0	60.9	359	
EPA2-CL5	12/12/94	NA	6.95	<0.1	0.3	1.0	11.4	<0.05	<0.05	<0.05	<0.05	1.7	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	236.0	125.0	86.8	448	
EPA2-CL5	12/29/94	NA	6.94	0.1	<0.1	<0.5	9.0	0.06	<0.05	<0.05	0.06	<0.5	NA	<1.0	<1.0	<1.0	1.0	1.0	<1.0	209.0	50.6	65.1	327	
EPA2-CL5	1/9/95	NA	7.03	<0.1	<0.1	<0.5	9.1	<0.05	<0.05	<0.05	<0.05	0.6	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	218.0	59.2	70.6	347	
EPA2-CL5	1/25/95	NA	6.94	0.2	<0.1	<0.5	9.9	<0.05	<0.05	<0.05	<0.05	4.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	166.0	46.4	57.6	270	
EPA2-CL5	2/6/95	NA	7.14	NA	<0.1	<0.5	6.7	<0.05	<0.05	<0.05	<0.05	6.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	15.8	15.8	102	
EPA2-CL5	2/21/95	NA	7.11	0.5	<0.1	<0.5	8.8	<0.05	<0.05	<0.05	<0.05	0.8	4.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	155.0	36.9	35.9	228
EPA2-CL5	3/6/95	NA	7.10	0.1	<0.1	<0.5	9.3	<0.05	<0.05	<0.05	<0.05	4.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	265.0	164.0	164.0	593	
EPA2-CL5	3/22/95	NA	6.92	0.1	<0.1	0.7	8.6	0.07	<0.05	<0.05	<0.05	1.0	3.7	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	255.0	142.0	223.0	620	
EPA2-CL5	4/3/95	NA	6.95	0.1	<0.1	<0.5	8.3	<0.05	<0.05	0.14	<0.05	1.0	4.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	149.0	58.9	39.0	247	
EPA2-CL5	4/17/95	NA	6.98	0.1	<0.1	<0.5	7.4	<0.05	<0.05	<0.05	<0.05	1.0	3.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	162.0	58.7	38.0	259	

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO	Fe (sol)	Br	Cl	NO ₃ -N	NO ₂ -N	NH ₄ -N	PO ₄ -P	SO ₄	S ₂ O ₃	BZ	TOL	ETBZ	PXVL	MXVL	OXYL	MESIT	PSCU	TMB	BTEXTMB
EPA3-CL1	4/25/94	NA	6.26	0.3	0.3	29.3	9.2	2.46	0.27	3.76	<0.05	16.5	NA	<1.0	3.7	12.7	20.9	38.9	34.7	40.6	24.8	45.6	222
EPA3-CL1	5/2/94	NA	5.96	0.1	0.2	15.4	8.4	1.74	0.69	1.25	<0.05	10.5	NA	<1.0	1.9	8.5	14.0	27.0	22.9	36.7	19.6	39.7	170
EPA3-CL1	5/16/94	NA	6.25	0.8	0.6	8.8	9.1	<0.05	2.80	0.10	0.10	6.1	NA	<1.0	2.9	7.1	11.8	23.0	18.3	29.5	18.1	36.4	147
EPA3-CL1	5/31/94	NA	6.51	0.1	0.1	4.7	9.9	1.87	0.50	4.18	0.07	3.7	NA	<1.0	6.0	7.2	11.5	22.9	17.4	37.9	19.2	35.0	137
EPA3-CL1	6/13/94	NA	6.14	0.1	0.2	4.9	6.3	<0.05	<0.05	1.83	0.06	0.8	NA	<1.0	3.8	7.6	11.2	23.5	17.4	29.1	16.7	28.0	137
EPA3-CL1	6/27/94	NA	6.01	0.2	0.1	8.6	5.7	<0.05	<0.05	1.29	<0.05	0.8	NA	<1.0	1.2	4.0	6.4	12.5	7.6	18.7	11.2	16.3	78
EPA3-CL1	7/11/94	NA	6.37	0.1	0.3	<0.53	2.5	<0.05	<0.05	0.88	<0.05	<0.5	NA	<1.0	<1.0	2.1	4.1	6.6	4.2	14.9	6.9	12.2	51
EPA3-CL1	7/25/94	NA	6.07	<0.1	0.5	2.4	9.2	<0.05	<0.05	1.85	<0.05	<0.5	NA	<1.0	3.6	3.1	4.7	9.4	6.5	17.3	9.1	15.1	69
EPA3-CL1	8/8/94	NA	6.51	<0.1	0.4	0.9	4.5	<0.05	<0.05	2.99	<0.05	<0.5	NA	<1.0	1.8	1.6	2.2	4.2	2.9	15.5	5.0	10.8	44
EPA3-CL1	8/23/94	NA	6.42	0.1	0.4	0.7	5.6	<0.05	<0.05	4.62	<0.05	<0.5	NA	<1.0	1.0	1.7	2.5	4.7	2.3	18.9	6.9	12.1	50
EPA3-CL1	9/6/94	NA	6.39	0.1	0.7	1.6	5.7	<0.05	<0.05	5.50	<0.05	<0.5	NA	<1.0	2.2	2.7	4.4	8.0	4.4	22.0	9.4	15.9	69
EPA3-CL1	9/19/94	NA	6.20	<0.1	0.9	2.4	11.0	0.06	<0.05	8.81	<0.05	6.1	NA	<1.0	2.3	2.6	4.0	7.9	4.6	18.2	8.0	13.2	61
EPA3-CL1	10/3/94	NA	6.44	0.1	1.0	0.8	8.1	0.14	0.10	3.15	<0.05	6.1	NA	<1.0	2.0	2.7	4.2	8.2	4.3	20.6	8.4	12.9	63
EPA3-CL1	10/17/94	NA	6.80	<0.1	0.6	<0.5	7.4	0.78	0.10	1.76	<0.05	8.7	NA	<1.0	1.0	1.7	2.8	5.0	2.5	17.5	6.6	9.8	47
EPA3-CL1	10/31/94	NA	6.85	<0.1	0.5	<0.5	8.6	0.10	<0.05	4.10	<0.05	2.8	NA	<1.0	<1.0	2.0	3.2	6.1	3.2	18.0	7.2	11.0	51
EPA3-CL1	11/11/94	NA	6.92	0.2	0.4	1.0	11.2	0.11	0.07	4.45	<0.05	8.6	NA	<1.0	<1.0	2.8	4.2	8.1	4.0	19.6	8.6	12.4	60
EPA3-CL1	11/30/94	NA	6.78	0.2	0.5	2.5	9.9	<0.05	<0.05	4.50	<0.05	4.9	NA	<1.0	1.0	3.4	5.1	9.9	5.5	15.1	8.0	11.1	59
EPA3-CL1	12/12/94	NA	6.71	0.1	0.5	1.2	7.9	0.08	<0.05	2.27	<0.05	4.6	NA	<1.0	<1.0	4.4	6.1	11.5	6.7	16.9	9.1	11.3	66
EPA3-CL1	12/29/94	NA	6.92	0.1	0.2	<0.5	8.9	<0.05	<0.05	1.10	<0.05	4.8	NA	<1.0	<1.0	5.4	7.6	12.2	8.5	16.6	9.3	10.2	70
EPA3-CL1	1/9/95	NA	7.06	0.1	0.1	<0.5	8.1	0.09	0.06	1.08	<0.05	4.7	NA	<1.0	<1.0	2.9	6.8	4.0	8.9	13.6	7.9	24.5	69
EPA3-CL1	1/25/95	NA	6.82	0.3	<0.1	0.8	7.8	0.49	0.12	1.21	<0.05	6.4	NA	<1.0	<1.0	2.8	6.8	4.0	8.9	13.6	7.9	24.5	69
EPA3-CL1	2/6/95	NA	6.92	0.5	0.1	<0.5	5.8	<0.05	<0.05	1.35	<0.05	4.2	NA	<1.0	<1.0	2.1	7.2	3.5	11.3	13.5	9.0	8.2	55
EPA3-CL1	2/21/95	NA	7.06	0.5	0.1	<0.5	7.7	<0.05	<0.05	3.01	<0.05	3.8	NA	<1.0	<1.0	1.5	6.1	2.7	13.2	12.6	8.1	7.2	51
EPA3-CL1	3/6/95	NA	7.06	0.1	0.4	<0.5	8.8	<0.05	<0.05	3.01	<0.05	3.8	NA	<1.0	<1.0	1.0	3.1	1.9	14.1	10.8	7.5	6.8	45
EPA3-CL1	3/22/95	NA	6.66	<0.1	0.2	1.2	9.1	0.42	0.15	1.18	<0.05	6.1	NA	<1.0	<1.0	1.0	3.3	2.2	17.8	11.2	8.4	7.2	51
EPA3-CL1	4/3/95	NA	6.58	0.1	0.2	<0.5	12.5	1.04	0.29	2.49	<0.05	9.8	0.5	<1.0	<1.0	<1.0	1.4	1.4	12.0	9.8	6.8	6.1	38
EPA3-CL1	4/17/95	NA	6.78	<0.1	0.3	<0.5	6.7	0.87	0.89	1.57	<0.05	8.3	<0.5	<1.0	<1.0	<1.0	<1.0	1.0	8.7	7.4	4.8	4.4	26
EPA3-CL1	4/28/95	NA	6.78	0.1	0.3	<0.5	4.9	1.67	0.72	1.49	<0.05	5.7	<0.5	<1.0	<1.0	<1.0	<1.0	1.0	7.3	7.5	5.6	5.1	27
EPA3-CL1	5/12/95	NA	6.97	0.1	<0.1	<0.5	11.6	1.91	2.03	2.55	<0.05	11.7	<0.5	<1.0	<1.0	<1.0	<1.0	1.1	7.3	7.5	5.6	5.1	27
EPA3-CL1	4/21/96	NA	5.78	<0.1	<0.1	<0.5	13.5	0.50	0.50	2.02	<0.05	69.7	<0.5	<1.0	2.7	2.9	4.4	8.2	5.3	6.2	5.8	5.5	41
EPA3-CL2	3/30/94	NA	4.90	0.3	4.5	4.0	3.5	0.06	<0.05	0.22	0.20	<0.5	NA	82.2	3050.0	1030.0	1190.0	3210.0	2400.0	165.0	651.0	283.0	12061
EPA3-CL2	4/7/94	NA	5.12	0.2	3.3	5.0	2.6	<0.05	<0.05	0.14	<0.05	3.0	NA	73.0	2900.0	999.0	1160.0	3220.0	2470.0	164.0	622.0	286.0	11906
EPA3-CL2	4/11/94	NA	4.90	<0.1	2.5	13.1	6.8	0.39	<0.05	0.21	<0.05	5.6	NA	71.2	2990.0	1080.0	1250.0	3470.0	2580.0	176.0	709.0	324.0	12650
EPA3-CL2	4/14/94	NA	4.72	0.1	2.9	21.2	12.9	2.33	<0.05	0.66	<0.05	15.1	NA	70.2	2650.0	1070.0	1200.0	2820.0	2410.0	178.0	592.0	305.0	11295
EPA3-CL2	4/18/94	NA	5.20	0.1	0.4	27.8	14.5	2.66	<0.05	0.85	<0.05	17.7	NA	71.5	2740.0	1100.0	1260.0	2990.0	2610.0	183.0	592.0	305.0	11295
EPA3-CL2	4/21/94	NA	4.95	0.2	4.1	33.3	13.2	2.20	<0.05	0.69	<0.05	17.1	NA	74.0	2900.0	1200.0	1340.0	3160.0	2720.0	185.0	686.0	352.0	12617
EPA3-CL2	4/25/94	NA	5.25	<0.1	3.0	40.1	11.3	0.87	<0.05	0.61	<0.05	15.9	NA	65.3	2640.0	1060.0	1190.0	2830.0	2400.0	179.0	594.0	298.0	11256
EPA3-CL2	5/2/94	NA	5.27	0.1	2.0	30.8	9.9	<0.05	<0.05	0.45	<0.05	5.5	NA	60.1	2370.0	963.0	1080.0	2730.0	2340.0	163.0	535.0	278.0	10519
EPA3-CL2	5/16/94	NA	5.76	0.8	1.0	15.1	8.9	<0.05	<0.05	1.40	<0.05	5.5	NA	57.4	2450.0	958.0	1080.0	2740.0	2330.0	161.0	523.0	276.0	10575
EPA3-CL2	5/31/94	NA	5.96	<0.1	1.0	7.7	9.8	0.13	<0.05	2.23	0.07	<0.5	NA	55.3	2410.0	1050.0	1110.0	2870.0	2370.0	180.0	613.0	300.0	10958
EPA3-CL2	6/13/94	NA	6.20	0.1	1.1	25.2	8.8	<0.05	<0.05	1.32	0.07	7.6	NA	35.4	1980.0	955.0	1070.0	3060.0	2270.0	180.0	624.0	305.0	10479
EPA3-CL2	6/27/94	NA	6.05	0.1	0.7	15.5	5.9	<0.05	<0.05	2.79	<0.05	<0.5	NA	27.0	1770.0	884.0	1020.0	2550.0	2090.0	158.0	550.0	278.0	9327
EPA3-CL2	7/11/94	NA	6.08	<0.1	0.5	2.5	2.8	<0.05	<0.05	1.64	<0.05	<0.5	NA	23.2	1730.0	893.0	1030.0	2610.0	2160.0	161.0	520.0	265.0	9424
EPA3-CL2	7/25/94	NA	5.85	<0.1	0.3	1.5	2.8	<0.05	<0.05	3.27	0.06	<0.5	NA	21.1	1660.0	978.0	993.0	2490.0	2100.0	174.0	577.0	309.0	9112
EPA3-CL2	8/8/94	NA	6.00	<0.1	0.5	2.4	9.2	<0.05	<0.05	4.88	<0.05	<0.5	NA	17.9	1610.0	766.0	903.0	2300.0	1930.0	154.0	478.0	245.0	8404
EPA3-CL2	8/23/94	NA	6.12	0.1	0.3	0.8	3.7	<0.05	<0.05	6.01	<0.05	<0.5	NA	19.4	1670.0	824.0	947.0	2450.0	2020.0	165.0	517.0	267.0	8879
EPA3-CL2	9/6/94	NA	6.13	0.1	0.4	1.9	3.8	0.07	<0.05	8.09	<0.05	2.0	NA	16.6	1780.0	871.0	999.0	2670.0	2010.0	159.0	543.0	318.0	9367
EPA3-CL2	9/19/94	NA	6.13	<0.1	0.2	1.7	10.9	0.07	<0.05	9.49	<0.05	<0.5	NA	16.8	1540.0	865.0	971.0	2300.0	1900.0	165.0	533.0	302.0	8593
EPA3-CL2	10/3/94	NA	6.26	<0.1	0.3	<0.5	8.1	0.10	<0.05	5.57	<0.05	1.1	NA	13.5	1380.0	820.0	915.0	2160.0	1810.0	163.0	522.0	289.0	8073
EPA3-CL2	10/17/94	NA	6.35	<0.1	0.4	<0.5	8.2	0.17	<0.05	5.59	0.07	<0.5	NA	13.7	1430.0	832.0	948.0	2210.0	1850.0	176.0	559.0	288.0	8307
EPA3-CL2	10/31/94	NA	6.45	<0.1	0.3	1.4	9.2	<0.05	<0.05	5.56	<0.05	1.9	NA	13.5	1320.0	791.0	894.0	2050.0	1740.0	167.0	538.0	275.0	7789

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S.O. (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEXTMB (ug/L)
EPA3-CL2	11/30/94	NA	6.50	<0.1	<0.1	<0.5	9.1	<0.05	<0.05	5.76	<0.05	<0.5	NA	16.3	1490.0	862.0	973.0	2430.0	1970.0	155.0	600.0	294.0	8790
EPA3-CL2	12/12/94	NA	6.63	0.1	0.1	1.5	8.6	<0.05	<0.05	4.36	<0.05	4.2	NA	15.3	1400.0	861.0	984.0	2410.0	2020.0	173.0	606.0	296.0	8745
EPA3-CL2	12/29/94	NA	6.82	0.1	<0.1	<0.5	8.7	<0.05	<0.05	2.63	<0.05	<0.5	NA	14.6	1470.0	887.0	1050.0	2640.0	2000.0	185.0	632.0	328.0	9207
EPA3-CL2	1/9/95	NA	6.88	0.1	<0.1	<0.5	9.0	<0.05	<0.05	1.76	<0.05	0.8	NA	13.2	1430.0	912.0	1050.0	2660.0	2020.0	179.0	680.0	327.0	9271
EPA3-CL2	1/25/95	NA	6.94	0.1	<0.1	<0.5	8.3	<0.05	<0.05	1.51	<0.05	0.8	NA	11.5	1240.0	880.0	1000.0	2380.0	1900.0	178.0	629.0	286.0	8475
EPA3-CL2	2/6/95	NA	7.05	NA	<0.1	<0.5	7.7	<0.05	<0.05	1.52	<0.05	4.7	NA	11.1	1360.0	882.0	968.0	2250.0	1990.0	193.0	613.0	325.0	8592
EPA3-CL2	2/21/95	NA	7.09	0.2	<0.1	<0.5	7.4	<0.05	<0.05	1.72	<0.05	4.7	1.2	10.3	1290.0	913.0	981.0	2340.0	2050.0	207.0	641.0	339.0	8771
EPA3-CL2	3/6/95	NA	7.13	<0.1	<0.1	<0.5	9.1	<0.05	<0.05	1.79	<0.05	2.2	NA	8.7	1190.0	833.0	913.0	2250.0	1880.0	188.0	620.0	314.0	8197
EPA3-CL2	3/22/95	NA	7.04	<0.1	<0.1	1.1	8.8	0.09	<0.05	1.82	<0.05	7.6	2.6	7.0	1080.0	835.0	912.0	2160.0	1830.0	186.0	613.0	315.0	7938
EPA3-CL2	4/3/95	NA	6.97	<0.1	<0.1	<0.5	8.0	<0.05	<0.05	2.28	<0.05	1.1	1.2	7.4	1140.0	884.0	954.0	2280.0	1930.0	196.0	644.0	331.0	8366
EPA3-CL2	4/17/95	NA	6.93	<0.1	0.2	1.1	8.3	0.75	<0.05	2.67	<0.05	8.5	<0.5	5.7	999.0	809.0	862.0	2070.0	1690.0	182.0	626.0	304.0	7548
EPA3-CL2	4/28/95	NA	6.84	0.1	0.2	1.2	9.9	1.14	0.12	2.50	<0.05	9.1	<0.5	4.8	926.0	786.0	831.0	1910.0	1670.0	181.0	601.0	314.0	7224
EPA3-CL2	5/12/95	NA	6.78	<0.1	<0.1	<0.5	11.1	<0.05	<0.05	3.35	<0.05	1.0	1.2	4.1	843.0	734.0	815.0	1990.0	1670.0	177.0	625.0	318.0	7176
EPA3-CL2	4/21/96	NA	5.76	0.1	<0.1	<0.5	3.1	0.50	0.50	1.22	<0.05	6.3	<0.5	4.9	153.0	732.0	793.0	1890.0	960.0	164.0	558.0	287.0	5562
EPA3-CL3	3/30/94	NA	5.30	0.3	6.5	3.6	3.9	<0.05	<0.05	1.35	0.14	<0.5	NA	51.3	4380.0	1120.0	1260.0	3350.0	2350.0	138.0	489.0	227.0	13365
EPA3-CL3	4/7/94	NA	5.70	0.2	5.8	5.0	3.0	<0.05	<0.05	1.21	<0.05	1.5	NA	58.1	4200.0	1090.0	1260.0	3370.0	2300.0	141.0	495.0	223.0	13137
EPA3-CL3	4/11/94	NA	5.45	0.1	4.2	5.4	3.1	<0.05	<0.05	1.21	<0.05	0.5	NA	82.4	4310.0	1140.0	1280.0	3410.0	2260.0	143.0	514.0	243.0	13382
EPA3-CL3	4/14/94	NA	5.29	0.1	5.2	5.2	3.1	<0.05	<0.05	1.39	<0.05	0.6	NA	101.0	4180.0	1170.0	1220.0	2950.0	2170.0	145.0	473.0	235.0	12644
EPA3-CL3	4/18/94	NA	5.76	<0.1	4.9	5.9	2.9	0.08	<0.05	1.42	<0.05	1.2	NA	123.0	4230.0	1150.0	1230.0	2890.0	2150.0	138.0	470.0	241.0	12622
EPA3-CL3	4/21/94	NA	5.47	0.1	5.1	4.7	3.0	<0.05	<0.05	1.30	<0.05	1.0	NA	139.0	4200.0	1140.0	1190.0	2880.0	2180.0	144.0	471.0	236.0	12580
EPA3-CL3	4/25/94	NA	6.19	<0.1	3.2	5.6	3.0	<0.05	<0.05	1.24	<0.05	1.0	NA	181.0	4190.0	1070.0	1150.0	2950.0	2150.0	134.0	438.0	232.0	12475
EPA3-CL3	5/2/94	NA	5.33	<0.1	4.6	7.5	10.9	<0.05	<0.05	0.96	<0.05	<0.5	NA	162.0	3780.0	1110.0	1080.0	2720.0	2090.0	116.0	380.0	208.0	11646
EPA3-CL3	5/16/94	NA	5.42	0.2	5.4	18.9	7.1	<0.05	<0.05	1.25	<0.05	5.4	NA	177.0	3790.0	1140.0	1130.0	2910.0	2240.0	122.0	388.0	213.0	12120
EPA3-CL3	5/31/94	NA	5.43	<0.1	6.1	27.9	8.7	0.12	<0.05	1.39	<0.05	7.7	NA	184.0	3970.0	1150.0	1120.0	3140.0	2220.0	133.0	439.0	231.0	12587
EPA3-CL3	6/13/94	NA	5.36	0.1	3.0	24.2	8.8	<0.05	<0.05	1.35	<0.05	7.6	NA	189.0	3790.0	1100.0	1040.0	2790.0	1990.0	127.0	404.0	215.0	11645
EPA3-CL3	6/27/94	NA	5.28	<0.1	4.3	15.7	9.0	<0.05	<0.05	1.31	<0.05	NA	NA	163.0	4190.0	1160.0	1040.0	3060.0	2180.0	125.0	420.0	211.0	12549
EPA3-CL3	7/11/94	NA	5.58	<0.1	4.8	14.3	7.0	<0.05	<0.05	1.87	<0.05	<0.5	NA	110.0	4250.0	1080.0	1050.0	2790.0	2120.0	113.0	378.0	208.0	12099
EPA3-CL3	7/25/94	NA	5.65	<0.1	3.5	7.7	4.9	<0.05	<0.05	1.93	<0.05	<0.5	NA	95.8	4530.0	1100.0	1110.0	2830.0	2250.0	116.0	369.0	215.0	12636
EPA3-CL3	8/8/94	NA	5.40	<0.1	2.9	5.0	4.8	<0.05	<0.05	2.05	<0.05	<0.5	NA	96.9	4180.0	990.0	1030.0	2540.0	2020.0	119.0	378.0	227.0	11581
EPA3-CL3	8/23/94	NA	5.61	0.1	2.4	2.1	6.5	<0.05	<0.05	2.53	<0.05	<0.5	NA	75.9	4460.0	942.0	985.0	2510.0	1990.0	109.0	331.0	189.0	11592
EPA3-CL3	9/6/94	NA	5.70	<0.1	3.6	3.7	6.3	<0.05	<0.05	2.33	<0.05	<0.5	NA	81.4	4520.0	990.0	1030.0	2710.0	2010.0	119.0	372.0	221.0	12053
EPA3-CL3	9/19/94	NA	5.66	<0.1	3.3	3.4	7.2	0.06	<0.05	3.08	<0.05	1.2	NA	110.0	4550.0	1160.0	1180.0	3230.0	2230.0	121.0	421.0	246.0	13248
EPA3-CL3	10/3/94	NA	5.77	<0.1	3.6	2.2	7.6	0.07	<0.05	4.81	<0.05	<0.5	NA	104.0	3860.0	1060.0	1080.0	2520.0	1950.0	119.0	395.0	206.0	11280
EPA3-CL3	10/17/94	NA	5.93	<0.1	4.3	<0.5	8.5	0.07	<0.05	2.34	<0.05	<0.5	NA	97.7	3850.0	1060.0	1080.0	2460.0	1940.0	116.0	371.0	221.0	11100
EPA3-CL3	10/31/94	NA	6.06	<0.1	5.8	1.1	8.7	0.08	<0.05	9.42	<0.05	<0.5	NA	95.0	3550.0	1060.0	1030.0	2480.0	2000.0	120.0	394.0	207.0	10936
EPA3-CL3	11/11/94	NA	6.17	<0.1	6.2	2.2	9.3	<0.05	<0.05	9.60	<0.05	<0.5	NA	90.2	3390.0	1010.0	1050.0	2420.0	1990.0	113.0	384.0	205.0	10652
EPA3-CL3	11/30/94	NA	6.18	<0.1	5.6	2.7	9.4	<0.05	<0.05	8.88	<0.05	<0.5	NA	88.4	3750.0	1180.0	1104.0	2690.0	2130.0	112.0	400.0	225.0	11679
EPA3-CL3	12/12/94	NA	6.31	<0.1	4.8	1.6	3.1	<0.05	<0.05	8.13	<0.05	<0.5	NA	79.7	3580.0	1040.0	1060.0	2580.0	2120.0	111.0	386.0	209.0	10866
EPA3-CL3	12/29/94	NA	6.48	0.1	4.2	<0.54	8.6	0.06	<0.05	7.28	<0.05	<0.5	NA	74.0	3580.0	1100.0	1150.0	2730.0	2180.0	123.0	424.0	216.0	11577
EPA3-CL3	1/9/95	NA	6.46	0.1	3.6	<0.5	8.6	<0.05	<0.05	6.30	<0.05	<0.5	NA	73.0	3620.0	1160.0	1200.0	2850.0	2230.0	128.0	436.0	223.0	11920
EPA3-CL3	1/25/95	NA	6.65	0.2	2.9	<0.5	8.9	<0.05	<0.05	5.54	<0.05	2.5	NA	67.9	3220.0	1130.0	1170.0	2820.0	2210.0	130.0	437.0	224.0	11409
EPA3-CL3	2/6/95	NA	6.77	NA	2.5	<0.5	8.7	<0.05	<0.05	4.87	<0.05	4.3	NA	65.4	3300.0	1160.0	1130.0	2690.0	2330.0	126.0	441.0	235.0	11477
EPA3-CL3	2/21/95	NA	6.78	0.1	2.0	<0.5	7.4	<0.05	<0.05	4.30	<0.05	<0.5	NA	56.6	3340.0	1210.0	1190.0	2820.0	2400.0	137.0	453.0	236.0	11843
EPA3-CL3	3/6/95	NA	6.83	<0.1	2.1	<0.5	9.1	<0.05	<0.05	3.53	<0.05	<0.5	NA	51.2	3150.0	1160.0	1140.0	2760.0	2210.0	135.0	439.0	223.0	11268
EPA3-CL3	3/22/95	NA	6.79	<0.1	1.5	1.0	8.6	0.06	<0.05	2.81	<0.05	<0.5	1.5	43.3	2910.0	1140.0	1140.0	2720.0	2180.0	127.0	429.0	221.0	10910
EPA3-CL3	4/3/95	NA	6.82	<0.1	1.2	<0.5	8.7	<0.05	<0.05	2.71	<0.05	<0.5	0.6	43.2	3000.0	1160.0	1130.0	2780.0	2250.0	137.0	469.0	230.0	11199
EPA3-CL3	4/17/95	NA	6.83	<0.1	1.4	0.9	8.3	<0.05	<0.05	2.67	<0.05	0.7	<0.5	45.0	2730.0	1190.0	1170.0	2880.0	2290.0	143.0	464.0	239.0	11151
EPA3-CL3	4/28/95	NA	6.77	0.1	1.4	1.0	8.8	<0.05	<0.05	2.48	<0.05	0.7	0.7	38.2	2240.0	1070.0	978.0	2530.0	2020.0	120.0	407.0	226.0	9629
EPA3-CL3	5/12/95	NA	6.81	0.1	1.0	<0.5	9.7	<0.05	<0.05	2.93	<0.05	<0.5	0.7	34.7	1650.0	1040.0	1010.0	2430.0	2020.0	122.0	410.0	206.0	8923
EPA3-CL3	4/21/96	NA	5.96	0.1	<0.1	<0.5	3.1	0.50	0.50	2.11	<0.05	<0.5	<0.5	7.9	272.0	1200.0	1120.0	2820.0	415.0	119.0	383.0	220.0	6657
EPA3-CL4	3/30/94	NA	5.80	0.2	3.0	3.5	4.3	<0.05	<0.05	1.83	<0.05	<0.5	NA	18.0	1890.0	1140.0	1						

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S ₂ O ₃ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEXMTB (ug/L)
EPA3-CL4	4/7/94	NA	6.16	0.1	4.1	3.3	3.2	<0.05	<0.05	1.69	<0.05	5.7	NA	9.5	1086.0	1070.0	1460.0	3770.0	973.0	235.0	809.0	306.0	10638
EPA3-CL4	4/11/94	NA	5.92	<0.1	2.7	2.6	2.8	<0.05	<0.05	1.66	<0.05	0.5	NA	11.7	1400.0	1140.0	1550.0	3970.0	1100.0	254.0	890.0	322.0	10093
EPA3-CL4	4/14/94	NA	5.75	<0.1	2.6	3.2	3.7	<0.05	<0.05	1.76	<0.05	0.5	NA	12.3	1470.0	1180.0	1510.0	3450.0	1110.0	244.0	798.0	319.0	10093
EPA3-CL4	4/19/94	NA	6.11	<0.1	2.4	3.2	2.8	<0.05	<0.05	1.85	<0.05	<0.5	NA	15.0	1690.0	1120.0	1370.0	3110.0	1200.0	228.0	742.0	307.0	9782
EPA3-CL4	4/21/94	NA	5.98	0.1	3.0	3.4	3.1	<0.05	<0.05	1.80	<0.05	<0.5	NA	16.8	1740.0	1140.0	1470.0	3220.0	1150.0	250.0	788.0	319.0	10094
EPA3-CL4	4/25/94	NA	6.19	<0.1	3.2	3.4	3.2	<0.05	<0.05	1.90	<0.05	<0.5	NA	22.1	1770.0	1060.0	1400.0	3270.0	1110.0	230.0	741.0	304.0	9927
EPA3-CL4	5/2/94	NA	5.84	0.1	3.0	5.1	3.6	<0.05	<0.05	1.83	<0.05	<0.5	NA	69.2	2480.0	1100.0	1390.0	3240.0	1220.0	220.0	757.0	288.0	10764
EPA3-CL4	5/16/94	NA	5.92	0.1	3.1	4.6	3.6	<0.05	<0.05	1.95	<0.05	<0.5	NA	163.0	2880.0	1080.0	1250.0	2950.0	1210.0	199.0	673.0	275.0	10680
EPA3-CL4	5/31/94	NA	5.86	<0.1	3.0	5.0	10.6	0.12	<0.05	1.97	<0.05	1.3	NA	344.0	4290.0	1090.0	1180.0	2930.0	1470.0	194.0	659.0	275.0	12432
EPA3-CL4	6/13/94	NA	5.66	<0.1	2.7	14.9	5.4	<0.05	<0.05	1.94	<0.05	1.9	NA	580.0	3720.0	1050.0	1060.0	2700.0	1480.0	176.0	599.0	249.0	11624
EPA3-CL4	6/27/94	NA	5.42	<0.1	3.4	20.0	8.2	<0.05	<0.05	2.02	<0.05	<0.5	NA	421.0	3740.0	1070.0	1060.0	3100.0	1620.0	151.0	532.0	226.0	11920
EPA3-CL4	7/11/94	NA	5.56	<0.1	3.2	16.5	8.5	<0.05	<0.05	2.12	<0.05	<0.5	NA	136.0	2750.0	1070.0	1100.0	2790.0	1380.0	154.0	520.0	248.0	10148
EPA3-CL4	7/25/94	NA	5.32	<0.1	3.3	15.3	11.4	<0.05	<0.05	2.15	<0.05	<0.5	NA	45.3	3150.0	1080.0	1140.0	2890.0	1860.0	147.0	488.0	227.0	11027
EPA3-CL4	8/9/94	NA	5.27	<0.1	2.2	11.3	6.8	<0.05	<0.05	2.38	<0.05	<0.5	NA	35.7	3290.0	1000.0	1090.0	2720.0	1830.0	144.0	461.0	240.0	10801
EPA3-CL4	8/23/94	NA	5.55	0.1	2.2	6.3	7.5	<0.05	<0.05	2.34	<0.05	<0.5	NA	21.4	2790.0	940.0	1030.0	2560.0	1720.0	130.0	396.0	198.0	9785
EPA3-CL4	9/6/94	NA	5.66	<0.1	2.7	8.6	10.3	<0.05	<0.05	2.15	<0.05	<0.5	NA	20.0	1870.0	1010.0	1130.0	2820.0	1500.0	147.0	453.0	237.0	9187
EPA3-CL4	9/19/94	NA	5.63	<0.1	2.2	4.5	4.8	0.06	<0.05	1.75	<0.05	<0.5	NA	72.1	2130.0	1080.0	1110.0	2880.0	1200.0	140.0	453.0	253.0	9318
EPA3-CL4	10/3/94	NA	5.68	<0.1	2.0	1.8	5.8	<0.05	<0.05	1.92	<0.05	<0.5	NA	78.6	1180.0	937.0	1010.0	2340.0	897.0	141.0	443.0	247.0	7274
EPA3-CL4	10/17/94	NA	5.63	<0.1	2.2	1.6	6.6	<0.05	<0.05	2.01	<0.05	<0.5	NA	106.0	2410.0	1110.0	1090.0	2590.0	1450.0	139.0	422.0	421.0	9728
EPA3-CL4	10/31/94	NA	5.70	<0.1	2.5	2.8	9.1	0.06	<0.05	2.76	<0.05	<0.5	NA	108.0	1640.0	1070.0	1070.0	2420.0	1660.0	126.0	424.0	238.0	8613
EPA3-CL4	11/1/94	NA	5.79	<0.1	3.0	2.8	10.3	<0.05	<0.05	5.89	<0.05	<0.5	NA	20.0	1870.0	1010.0	1130.0	2820.0	1500.0	147.0	453.0	253.0	9318
EPA3-CL4	11/15/94	NA	5.80	<0.1	3.9	3.4	9.9	<0.05	<0.05	6.16	<0.05	<0.5	NA	152.0	2160.0	1040.0	1070.0	2610.0	1440.0	119.0	419.0	219.0	8624
EPA3-CL4	11/30/94	NA	6.00	<0.1	4.5	2.5	9.2	<0.05	<0.05	7.14	<0.05	<0.5	NA	257.0	1440.0	1050.0	1070.0	2610.0	1440.0	119.0	419.0	219.0	8624
EPA3-CL4	12/12/94	NA	6.31	0.1	7.6	0.7	9.5	0.06	<0.05	9.40	<0.05	<0.5	NA	456.0	917.0	1050.0	1090.0	2550.0	1130.0	123.0	434.0	214.0	7964
EPA3-CL4	12/29/94	NA	6.28	<0.1	7.6	1.9	10.9	<0.05	<0.05	5.85	<0.05	<0.5	NA	217.0	1920.0	1050.0	1080.0	2600.0	1590.0	125.0	434.0	213.0	9229
EPA3-CL4	1/9/95	NA	6.36	0.1	7.6	1.6	8.6	<0.05	<0.05	5.85	<0.05	<0.5	NA	182.0	1470.0	1160.0	1140.0	2700.0	1870.0	138.0	450.0	229.0	9339
EPA3-CL4	1/25/95	NA	6.48	NA	6.5	<0.5	9.2	<0.05	<0.05	5.34	<0.05	0.8	NA	318.0	637.0	1120.0	1200.0	2760.0	1390.0	142.0	481.0	247.0	8295
EPA3-CL4	2/6/95	NA	6.47	0.1	6.0	1.8	9.2	<0.05	<0.05	3.34	<0.05	1.3	0.7	414.0	204.0	1090.0	1130.0	2680.0	843.0	139.0	489.0	235.0	7224
EPA3-CL4	2/21/95	NA	6.50	<0.1	6.2	NA	10.3	<0.05	<0.05	2.17	<0.05	<0.5	NA	239.0	509.0	1190.0	1100.0	2600.0	1230.0	143.0	472.0	212.0	7545
EPA3-CL4	3/6/95	NA	6.45	<0.1	3.6	1.2	8.7	0.08	<0.05	1.76	<0.05	<0.5	1.4	239.0	509.0	1190.0	1100.0	2600.0	918.0	151.0	534.0	243.0	7426
EPA3-CL4	3/22/95	NA	6.45	<0.1	3.3	<0.5	8.9	<0.05	<0.05	1.55	<0.05	<0.5	<0.5	308.0	112.0	1190.0	1190.0	2940.0	1420.0	159.0	566.0	263.0	8038
EPA3-CL4	4/3/95	NA	6.51	<0.1	3.1	0.8	8.5	<0.05	<0.05	1.68	<0.05	<0.5	<0.5	135.0	205.0	1160.0	1190.0	2940.0	1420.0	159.0	566.0	263.0	8038
EPA3-CL4	4/17/95	NA	6.57	0.1	3.1	1.0	8.5	<0.05	<0.05	3.04	<0.05	<0.5	0.5	48.5	33.2	1060.0	997.0	2640.0	371.0	136.0	469.0	234.0	5991
EPA3-CL4	4/28/95	NA	6.56	0.1	3.4	1.0	8.5	<0.05	<0.05	2.08	<0.05	<0.5	<0.5	36.3	24.2	1070.0	1070.0	2670.0	136.0	142.0	467.0	238.0	5854
EPA3-CL4	5/12/95	NA	6.65	<0.1	2.5	<0.5	8.4	<0.05	<0.05	2.67	<0.05	<0.5	<0.5	1.9	24.3	914.0	1080.0	2560.0	23.4	208.0	673.0	299.0	5794
EPA3-CL4	4/21/96	NA	6.02	0.5	<0.1	<0.5	5.4	<0.05	<0.05	2.67	<0.05	0.9	<0.5	1.9	24.3	914.0	1080.0	2560.0	23.4	208.0	673.0	299.0	5794
EPA3-CL5	3/30/94	NA	5.80	0.2	3.9	4.4	3.5	<0.05	<0.05	1.75	<0.05	<0.5	NA	17.5	38.4	92.0	338.0	615.0	235.0	70.8	182.0	112.0	1499
EPA3-CL5	4/7/94	NA	6.15	0.1	4.2	3.5	3.0	<0.05	<0.05	1.79	<0.05	8.9	NA	15.6	34.9	163.0	476.0	872.0	239.0	73.6	209.0	107.0	1975
EPA3-CL5	4/11/94	NA	5.94	<0.1	3.4	2.9	2.5	<0.05	<0.05	1.72	<0.05	<0.5	NA	19.4	28.3	136.0	440.0	715.0	284.0	77.0	235.0	115.0	1794
EPA3-CL5	4/14/94	NA	5.75	<0.1	4.1	3.2	3.5	<0.05	<0.05	1.82	<0.05	<0.5	NA	21.1	40.3	139.0	460.0	719.0	38.8	79.9	225.0	112.0	1835
EPA3-CL5	4/18/94	NA	6.10	<0.1	4.1	3.7	2.4	<0.05	<0.05	1.88	<0.05	<0.5	NA	18.9	45.2	172.0	795.0	26.4	45.3	73.7	212.0	96.8	1485
EPA3-CL5	4/21/94	NA	6.04	<0.1	4.5	3.0	3.0	<0.05	<0.05	1.85	<0.05	<0.5	NA	18.1	43.2	228.0	570.0	975.0	51.6	83.4	234.0	106.0	2309
EPA3-CL5	4/25/94	NA	6.24	0.1	4.8	3.6	3.1	<0.05	<0.05	1.95	<0.05	<0.5	NA	17.4	66.3	294.0	697.0	1210.0	51.4	85.1	265.0	105.0	2791
EPA3-CL5	5/2/94	NA	5.92	0.3	4.5	4.1	3.4	<0.05	<0.05	1.70	<0.05	<0.5	NA	24.3	232.0	499.0	915.0	1630.0	66.5	89.9	300.0	103.0	3860
EPA3-CL5	5/16/94	NA	6.08	<0.1	4.2	2.7	3.1	<0.05	<0.05	1.64	<0.05	<0.5	NA	25.0	756.0	846.0	1260.0	2520.0	774.0	188.0	604.0	252.0	9335
EPA3-CL5	5/31/94	NA	6.00	<0.1	5.6	8.8	4.3	0.14	<0.05	2.18	<0.05	0.8	NA	507.0	1590.0	1050.0	1350.0	3040.0	774.0	113.0	390.0	159.0	6356
EPA3-CL5	6/13/94	NA	5.92	0.1	3.9	29.4	8.5	<0.05	<0.05	2.50	<0.05	8.5	NA	946.0	443.0	1020.0	1190.0	2630.0	806.0	179.0	648.0	251.0	8113
EPA3-CL5	6/27/94	NA	5.78	<0.1	3.4	17.1	9.1	<0.05	<0.05	2.32	<0.05	<0.5	NA	1070.0	969.0	1140.0	1200.0	2910.0	677.0	179.0	619.0	246.0	8210
EPA3-CL5	7/11/94	NA	5.70	<0.1	4.2	10.9	5.0	<0.05	<0.05	2.17	<0.05	<0.5	NA	653.0	946.0	866.0	1160.0	2880.0	875.0	154.0	514.0	200.0	8048
EPA3-CL5	7/25/94	NA	5.76	<0.1	4.2	11.9	7.1	<0.05	<0.05	2.15	<0.05	<0.5	NA	289.0	1110.0	875.0	1190.0	2880.0	919.0	163.0	530.0	198.0	8154
EPA3-CL5	8/6/94	NA	5.50	<0.1	3.0	12.2	11.7	<0.05	<0.05	2.33	<0.05	<0.5	NA	<1.0	1.4	19	3.2	5.6	3.0	16.3	7.1	13.7	

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S.O. ₄ (mg/L)	BZ (mg/L)	TOL (μg/L)	ETBZ (μg/L)	PXYL (μg/L)	MXYL (μg/L)	OXYL (μg/L)	MESIT (μg/L)	PSCU (μg/L)	TMB (μg/L)	BTEXTMB (μg/L)
EPA3-CL5	9/19/94	NA	5.72	<0.1	2.6	4.0	9.6	0.07	<0.05	2.20	<0.05	<0.5	NA	34.9	83.0	1020.0	1220.0	2220.0	1080.0	163.0	538.0	246.0	6605
EPA3-CL5	10/3/94	NA	5.74	<0.1	2.2	6.0	7.5	<0.05	<0.05	2.42	<0.05	<0.5	NA	36.7	99.8	1010.0	1200.0	2440.0	925.0	182.0	546.0	272.0	6712
EPA3-CL5	10/17/94	NA	5.79	<0.1	2.7	3.1	6.4	<0.05	<0.05	1.44	<0.05	<0.5	NA	58.4	149.0	975.0	1130.0	2090.0	921.0	169.0	525.0	240.0	6257
EPA3-CL5	10/31/94	NA	5.82	<0.1	2.6	3.0	6.2	0.33	<0.05	2.06	<0.05	<0.5	NA	76.2	144.0	1050.0	1130.0	2080.0	1180.0	173.0	538.0	245.0	6616
EPA3-CL5	11/11/94	NA	5.77	<0.1	2.5	4.0	9.7	<0.05	<0.05	2.25	<0.05	0.7	NA	107.0	228.0	1040.0	1100.0	2130.0	1440.0	167.0	531.0	242.0	6995
EPA3-CL5	11/30/94	NA	5.78	0.1	2.3	3.2	10.0	<0.05	<0.05	2.49	<0.05	<0.5	NA	103.0	53.2	1070.0	1080.0	2070.0	778.0	130.0	442.0	219.0	5945
EPA3-CL5	12/12/94	NA	6.10	<0.1	3.0	3.0	9.9	<0.05	<0.05	3.96	<0.05	<0.5	NA	457.0	63.3	1060.0	1140.0	2430.0	918.0	141.0	472.0	224.0	6905
EPA3-CL5	12/29/94	NA	6.16	<0.1	4.0	1.7	10.0	0.07	<0.05	6.23	<0.05	<0.5	NA	970.0	48.2	1120.0	1080.0	2410.0	111.0	138.0	462.0	217.0	6556
EPA3-CL5	1/9/95	NA	6.20	<0.1	3.4	2.4	9.5	<0.05	<0.05	3.12	<0.05	<0.5	NA	553.0	57.5	1180.0	817.0	1800.0	84.3	144.0	470.0	231.0	5337
EPA3-CL5	1/25/95	NA	6.25	0.1	2.9	1.6	9.4	<0.05	<0.05	2.02	<0.05	<0.5	NA	324.0	51.4	1200.0	386.0	1200.0	70.1	152.0	492.0	216.0	4092
EPA3-CL5	2/6/95	NA	6.39	NA	3.2	<0.5	9.0	<0.05	<0.05	3.63	<0.05	<0.5	NA	637.0	37.9	1380.0	268.0	1070.0	51.0	161.0	526.0	217.0	4348
EPA3-CL5	2/21/95	NA	6.36	0.2	2.9	1.8	9.1	<0.05	<0.05	3.10	<0.05	<0.5	NA	743.0	38.3	1400.0	285.0	1080.0	48.6	171.0	589.0	214.0	4569
EPA3-CL5	3/6/95	NA	6.48	<0.1	2.8	<0.5	7.8	<0.05	<0.05	1.36	<0.05	<0.5	NA	398.0	47.0	1530.0	379.0	1450.0	58.4	194.0	666.0	222.0	4944
EPA3-CL5	3/22/95	NA	6.41	<0.1	1.8	<0.5	8.7	0.08	<0.05	1.19	<0.05	<0.5	NA	268.0	44.0	1460.0	563.0	1850.0	57.6	189.0	653.0	221.0	5306
EPA3-CL5	4/3/95	NA	6.50	<0.1	1.8	<0.5	8.8	<0.05	<0.05	1.01	<0.05	<0.5	NA	263.0	37.7	1540.0	573.0	2260.0	52.6	205.0	750.0	246.0	5927
EPA3-CL5	4/17/95	NA	6.52	<0.1	2.1	1.2	9.0	<0.05	<0.05	0.78	<0.05	<0.5	NA	214.0	40.4	1610.0	532.0	2370.0	62.6	229.0	775.0	280.0	6113
EPA3-CL5	4/28/95	NA	6.42	0.1	3.3	1.1	8.9	<0.05	<0.05	0.70	<0.05	<0.5	NA	664.0	37.5	1320.0	395.0	1750.0	54.1	182.0	648.0	235.0	5286
EPA3-CL5	5/12/95	NA	6.40	<0.1	2.3	<0.5	8.2	<0.05	<0.05	0.99	<0.05	<0.5	NA	475.0	29.3	1240.0	408.0	1920.0	149.0	179.0	653.0	243.0	5296
EPA3-CL5	4/21/96	NA	6.06	<0.1	<0.1	<0.5	11.4	0.50	0.50	2.16	<0.05	<0.5	NA	2.1	3.5	505.0	283.0	1700.0	10.2	123.0	415.0	83.7	3126
EPA4-CL1	3/30/94	NA	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)
EPA4-CL1	4/7/94	NA	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)
EPA4-CL1	4/11/94	NA	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)
EPA4-CL1	4/14/94	NA	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)
EPA4-CL1	4/18/94	NA	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)
EPA4-CL1	4/21/94	NA	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)
EPA4-CL1	4/25/94	NA	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)
EPA4-CL1	5/2/94	NA	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)
EPA4-CL1	5/16/94	NA	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)
EPA4-CL1	5/31/94	NA	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)
EPA4-CL1	6/13/94	NA	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)
EPA4-CL1	6/27/94	NA	6.52	0.4	0.5	2.6	24.0	0.23	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	1.0	3.4	5.5	5.9	1.3	2.6	2.2	22
EPA4-CL1	7/11/94	NA	6.69	0.1	0.7	0.9	3.7	<0.05	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	1.0	7.5	5.7	7.0	1.6	3.9	2.8	30
EPA4-CL1	7/25/94	NA	6.55	<0.1	1.3	1.3	1.5	<0.05	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	5.8	3.7	8.5	14.4	17.0	2.8	5.6	4.9
EPA4-CL1	8/8/94	NA	6.46	<0.1	2.3	1.9	4.5	<0.05	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	2.8	1.9	4.5	6.8	8.5	2.2	4.0	3.8
EPA4-CL1	8/23/94	NA	6.35	0.2	3.7	1.0	1.0	<0.05	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	3.8	2.1	4.8	7.2	9.6	2.4	4.0	3.9
EPA4-CL1	9/6/94	NA	6.37	0.4	2.1	1.4	3.7	0.06	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	1.5	1.8	3.6	4.6	7.8	2.0	3.9	4.1
EPA4-CL1	9/19/94	NA	6.22	0.1	3.5	2.9	24.3	0.68	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	1.2	1.1	2.2	3.1	4.7	1.6	2.1	2.5
EPA4-CL1	10/3/94	NA	6.79	0.1	1.2	2.0	15.5	0.08	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	1.0	1.1	1.5	2.3	1.0	1.4	1.7	11
EPA4-CL1	10/17/94	NA	6.60	<0.1	1.4	<0.5	4.1	0.17	<0.05	0.33	<0.05	<0.5	NA	<1.0	<1.0	1.0	2.1	2.4	5.3	2.0	3.2	3.5	22
EPA4-CL1	10/31/94	NA	6.69	0.1	1.6	<0.5	10.3	0.09	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	1.7	2.3	2.6	4.7	1.6	2.6	2.8	18
EPA4-CL1	11/11/94	NA	6.66	0.2	1.3	2.6	13.1	<0.05	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	1.7	2.0	1.6	3.4	1.7	3.0	2.8	16
EPA4-CL1	11/30/94	NA	6.63	4.8	<0.1	<0.5	11.6	1.02	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	1.4	1.1	<1.0	1.8	4
EPA4-CL1	12/12/94	NA	6.82	2.1	<0.1	0.8	9.6	0.24	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	<1.0	<1.0	1.1	2
EPA4-CL1	12/29/94	NA	6.99	6.1	<0.1	<0.5	10.7	0.18	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.1	<1.0	1.4	5
EPA4-CL1	1/9/95	NA	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)
EPA4-CL1	1/25/95	NA	7.00	5.0	<0.1	<0.5	8.9	0.19	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.1	1
EPA4-CL1	2/6/95	NA	7.08	NA	<0.1	<0.5	8.3	0.12	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.4	3
EPA4-CL1	2/21/95	NA	7.06	4.9	<0.1	<0.5	8.9	0.11	<0.05	<0.05	<0.05	<0.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.1	1
EPA4-CL1	3/6/95	NA	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)	(dry)									

APPENDIX C (cont.)

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S ₂ O ₃ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEX(MIB) (ug/L)
EPA4-CL1	4/28/95	NA	6.82	2.1	<0.1	1.8	8.2	0.20	<0.05	<0.05	<0.05	10.0	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1
EPA4-CL1	5/12/95	NA	6.80	1.3	<0.1	<0.5	8.1	0.14	<0.05	<0.05	<0.05	11.5	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
EPA4-CL1	4/21/96	NA	6.88	4.7	<0.1	<0.5	0.9	0.50	0.50	<0.05	<0.05	1.5	<0.5	<1.0	<1.0	<1.0	1.4	2.3	1.2	<1	1.7	1.2	8
EPA4-CL2	3/30/94	NA	6.00	0.3	3.1	2.5	3.2	4.38	1.13	0.18	<0.05	9.3	NA	<1.0	1.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2
EPA4-CL2	4/7/94	NA	6.32	0.1	2.4	1.5	5.6	<0.05	<0.05	0.07	<0.05	1.4	NA	<1.0	7.4	2.3	3.6	6.8	4.4	<1.0	1.0	<1.0	26
EPA4-CL2	4/11/94	NA	5.94	0.2	2.2	0.6	4.6	0.78	<0.05	0.46	<0.05	43.8	NA	<1.0	11.2	2.3	4.8	8.3	6.2	1.9	3.1	1.8	40
EPA4-CL2	4/14/94	NA	6.41	1.2	0.9	<0.5	30.4	0.09	<0.05	<0.05	<0.05	71.3	NA	<1.0	8.9	2.5	4.5	8.7	6.4	1.2	2.1	1.8	36
EPA4-CL2	4/18/94	NA	6.39	0.3	1.4	<0.5	85.5	0.07	<0.05	<0.05	<0.05	67.6	NA	<1.0	14.7	4.0	15.5	<1.0	11.6	1.2	2.7	1.9	52
EPA4-CL2	4/21/94	NA	6.63	0.8	1.0	<0.5	89.7	<0.05	<0.05	<0.05	<0.05	35.0	NA	<1.0	16.7	5.1	9.7	18.7	15.0	1.6	3.0	2.1	72
EPA4-CL2	4/25/94	NA	6.49	0.1	1.2	<0.5	76.8	<0.05	<0.05	<0.05	<0.05	24.5	NA	<1.0	14.5	6.8	13.2	25.6	20.8	1.7	3.7	2.5	89
EPA4-CL2	5/2/94	NA	6.72	0.1	2.2	<0.5	101.0	<0.05	<0.05	<0.05	<0.05	12.9	NA	<1.0	24.5	13.5	19.6	41.0	33.6	2.7	7.8	4.1	147
EPA4-CL2	5/16/94	NA	6.63	0.6	1.1	2.8	29.1	<0.05	<0.05	<0.05	<0.05	2.4	NA	<1.0	23.3	15.3	21.7	40.7	37.2	3.5	10.4	5.4	158
EPA4-CL2	5/31/94	NA	6.78	<0.1	2.1	1.5	10.5	0.16	<0.05	<0.05	<0.05	11.0	NA	<1.0	30.7	20.7	25.2	50.7	48.1	6.0	17.0	9.0	207
EPA4-CL2	6/13/94	NA	6.60	<0.1	1.4	2.4	10.0	<0.05	<0.05	<0.05	<0.05	6.2	NA	<1.0	38.3	23.0	24.5	56.2	48.6	5.3	15.3	8.3	220
EPA4-CL2	6/27/94	NA	6.57	0.1	1.4	<0.5	47.7	<0.05	<0.05	<0.05	<0.05	NA	NA	<1.0	12.5	9.1	9.5	21.2	19.3	1.9	5.0	3.3	82
EPA4-CL2	7/11/94	NA	6.79	0.1	0.3	0.9	3.6	<0.05	<0.05	<0.05	<0.05	2.0	NA	<1.0	13.7	9.9	11.8	24.7	22.4	2.4	7.1	4.2	96
EPA4-CL2	7/25/94	NA	6.50	<0.1	0.5	1.0	4.5	<0.05	<0.05	<0.05	<0.05	0.5	NA	<1.0	22.4	15.4	17.8	36.4	34.7	3.3	9.6	6.3	146
EPA4-CL2	8/6/94	NA	6.36	<0.1	1.3	1.7	3.1	<0.05	<0.05	<0.05	<0.05	1.4	NA	<1.0	9.1								

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	SO ₃ (mg/L)	BZ (ug/L)	TOI (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEXTMIB (ug/L)
EPA4-CL3	7/11/94	NA	6.50	0.1	0.5	0.8	5.5	<0.05	<0.05	<0.05	<0.05	1.1	NA	<1.0	1120.0	281.0	1010.0	2000.0	2520.0	337.0	938.0	523.0	8729
EPA4-CL3	7/25/94	NA	6.19	<0.1	1.2	1.7	22.6	0.14	<0.05	0.50	<0.05	5.7	NA	<1.0	359.0	129.0	653.0	1700.0	1750.0	373.0	910.0	564.0	5908
EPA4-CL3	8/8/94	NA	6.00	<0.1	1.8	2.2	22.6	0.24	<0.05	0.92	<0.05	11.8	NA	<1.0	638.0	209.0	947.0	1840.0	2280.0	349.0	901.0	554.0	7718
EPA4-CL3	8/23/94	NA	5.82	<0.1	11.2	2.5	10.3	<0.05	<0.05	7.49	<0.05	2.1	NA	17.4	11500.0	1340.0	2030.0	4440.0	4320.0	304.0	927.0	488.0	25366
EPA4-CL3	9/6/94	NA	6.17	<0.1	10.5	3.3	8.8	<0.05	<0.05	4.49	<0.05	1.9	NA	13.5	5530.0	839.0	1430.0	3060.0	2940.0	315.0	978.0	477.0	15583
EPA4-CL3	9/19/94	NA	6.22	0.1	1.0	2.0	10.9	0.06	<0.05	0.07	<0.05	1.3	NA	1.0	276.0	131.0	602.0	1090.0	1050.0	285.0	842.0	515.0	4714
EPA4-CL3	10/3/94	NA	6.65	0.1	1.2	3.0	12.1	<0.05	<0.05	<0.05	<0.05	4.6	NA	<1.0	305.0	154.0	797.0	1380.0	2030.0	342.0	842.0	569.0	6419
EPA4-CL3	10/17/94	NA	6.56	<0.1	0.7	<0.5	5.7	0.09	<0.05	0.32	<0.05	3.2	NA	<1.0	44.8	62.4	385.0	576.0	672.0	327.0	747.0	525.0	3339
EPA4-CL3	10/31/94	NA	6.72	0.1	1.4	<0.5	4.8	0.08	<0.05	<0.05	<0.05	<0.5	NA	<1.0	33.6	71.9	571.0	921.0	776.0	369.0	892.0	553.0	4198
EPA4-CL3	11/11/94	NA	6.58	<0.1	0.8	1.9	9.1	<0.05	<0.05	<0.05	<0.05	0.8	NA	<1.0	37.0	56.6	419.0	685.0	522.0	342.0	790.0	512.0	3364
EPA4-CL3	11/30/94	NA	6.58	<0.1	0.5	<0.5	12.2	<0.05	<0.05	<0.05	<0.05	7.3	NA	<1.0	54.6	46.6	355.0	634.0	462.0	292.0	758.0	481.0	3083
EPA4-CL3	12/12/94	NA	6.73	0.1	0.2	<0.5	9.7	<0.05	<0.05	<0.05	<0.05	2.1	NA	<1.0	40.3	36.0	272.0	456.0	302.0	303.0	778.0	455.0	2642
EPA4-CL3	12/29/94	NA	6.73	0.1	<0.1	<0.5	10.0	0.06	<0.05	<0.05	<0.05	0.7	NA	<1.0	36.2	26.9	171.0	306.0	150.0	306.0	734.0	435.0	2165
EPA4-CL3	1/9/95	NA	6.82	0.1	<0.1	<0.5	7.0	<0.05	<0.05	<0.05	<0.05	1.6	NA	<1.0	22.7	19.1	133.0	240.0	113.0	338.0	754.0	470.0	2090
EPA4-CL3	1/25/95	NA	6.93	0.2	<0.1	<0.5	9.6	<0.05	<0.05	<0.05	<0.05	3.6	NA	<1.0	21.8	17.1	84.6	128.0	77.7	334.0	709.0	452.0	1824
EPA4-CL3	2/6/95	NA	6.97	NA	<0.1	<0.5	7.3	<0.05	<0.05	<0.05	<0.05	1.2	NA	<1.0	32.9	20.9	76.2	136.0	69.7	331.0	683.0	451.0	1803
EPA4-CL3	2/21/95	NA	6.91	0.3	<0.1	<0.5	8.2	<0.05	<0.05	<0.05	<0.05	4.0	NA	<1.0	21.0	13.9	44.1	65.5	39.8	350.0	641.0	413.0	1588
EPA4-CL3	3/6/95	NA	6.92	<0.1	<0.1	<0.5	7.8	<0.05	<0.05	<0.05	<0.05	5.0	NA	<1.0	20.7	12.6	34.4	55.9	34.2	322.0	633.0	400.0	1513
EPA4-CL3	3/22/95	NA	6.85	0.3	<0.1	1.1	7.7	0.07	<0.05	<0.05	<0.05	0.8	NA	<1.0	13.6	8.7	16.9	28.1	34.4	344.0	548.0	334.0	1312
EPA4-CL3	4/3/95	NA	6.77	0.1	<0.1	<0.5	9.0	<0.05	<0.05	<0.05	<0.05	1.4	NA	<1.0	12.0	7.1	12.7	23.9	15.6	294.0	478.0	295.0	1138
EPA4-CL3	4/17/95	NA	6.89	0.2	<0.1	1.4	9.7	<0.05	<0.05	<0.05	<0.05	1.0	NA	<1.0	17.1	10.5	14.2	28.4	19.8	304.0	498.0	284.0	1176
EPA4-CL3	4/28/95	NA	6.80	<0.1	<0.1	1.6	8.7	<0.05	<0.05	<0.05	<0.05	0.9	NA	<1.0	11.1	8.0	11.5	22.5	15.0	291.0	478.0	297.0	1134
EPA4-CL3	5/12/95	NA	6.84	0.1	<0.1	<0.5	10.1	<0.05	<0.05	<0.05	<0.05	1.6	NA	<1.0	6.6	6.6	8.2	15.7	12.5	267.0	382.0	233.0	932
EPA4-CL3	4/21/96	NA	5.84	0.2	<0.1	<0.5	16.7	0.50	0.50	0.75	<0.05	1.0	<0.5	13.0	6380.0	2070.0	2800.0	6550.0	6070.0	507.0	1670.0	652.0	26712
EPA4-CL4	3/30/94	NA	5.90	0.2	2.2	<0.5	<0.5	<0.05	<0.05	0.28	<0.05	4.9	NA	13.3	7310.0	1840.0	3050.0	7760.0	4860.0	516.0	2070.0	620.0	28039
EPA4-CL4	4/7/94	NA	6.24	<0.1	1.7	2.0	3.0	<0.05	<0.05	0.17	<0.05	<0.5	NA	12.4	507.0	205.0	461.0	1390.0	389.0	216.0	576.0	173.0	3929
EPA4-CL4	4/11/94	NA	5.78	<0.1	2.5	2.1	4.7	<0.05	<0.05	0.47	<0.05	0.8	NA	94.2	7160.0	1800.0	3240.0	8020.0	6240.0	556.0	2220.0	706.0	30036
EPA4-CL4	4/14/94	NA	5.79	0.2	5.4	3.2	5.6	<0.05	<0.05	1.64	<0.05	1.8	NA	61.2	10600.0	2790.0	3930.0	8720.0	7210.0	657.0	2330.0	801.0	37059
EPA4-CL4	4/18/94	NA	6.27	0.1	7.6	<0.5	27.6	<0.05	0.13	0.63	<0.05	23.6	NA	6.0	1620.0	1070.0	2060.0	4220.0	3820.0	550.0	1580.0	638.0	15564
EPA4-CL4	4/21/94	NA	6.60	0.2	2.7	<0.5	87.4	<0.05	<0.05	<0.05	<0.05	47.9	NA	3.4	604.0	832.0	1740.0	3540.0	3420.0	391.0	1190.0	528.0	12248
EPA4-CL4	4/25/94	NA	6.44	0.2	1.4	<0.5	81.5	<0.05	<0.05	<0.05	<0.05	36.7	NA	1.5	582.0	942.0	2070.0	4120.0	3940.0	399.0	1230.0	543.0	13828
EPA4-CL4	5/2/94	NA	6.17	0.3	0.6	<0.5	91.8	<0.05	<0.05	<0.05	<0.05	26.0	NA	<1.0	305.0	694.0	1600.0	3160.0	3400.0	351.0	1030.0	501.0	11041
EPA4-CL4	5/16/94	NA	6.15	<0.1	0.2	1.0	10.1	<0.05	<0.05	<0.05	<0.05	15.1	NA	<1.0	70.0	334.0	1110.0	2050.0	2470.0	310.0	813.0	492.0	7649
EPA4-CL4	5/31/94	NA	6.65	<0.1	0.3	1.4	13.1	0.16	<0.05	<0.05	<0.05	8.8	NA	1.6	101.0	227.0	1010.0	2000.0	2120.0	333.0	955.0	486.0	7244
EPA4-CL4	6/13/94	NA	6.23	0.1	0.2	2.1	10.4	<0.05	<0.05	<0.05	<0.05	12.0	NA	4.2	79.7	304.0	1130.0	2230.0	2470.0	323.0	929.0	481.0	7951
EPA4-CL4	6/27/94	NA	6.44	<0.1	0.4	2.8	8.4	<0.05	<0.05	<0.05	<0.05	NA	NA	1.6	5170.0	988.0	1730.0	3890.0	4130.0	294.0	795.0	463.0	17462
EPA4-CL4	7/11/94	NA	6.55	<0.1	0.2	2.4	23.2	<0.05	<0.05	<0.05	<0.05	9.1	NA	9.9	7310.0	2790.0	3990.0	9080.0	7380.0	473.0	1970.0	678.0	33681
EPA4-CL4	7/25/94	NA	5.74	<0.1	1.4	3.8	3.6	<0.05	<0.05	1.29	<0.05	0.6	NA	51.7	8150.0	2340.0	3840.0	8240.0	6740.0	695.0	2870.0	933.0	33860
EPA4-CL4	8/8/94	NA	5.67	<0.1	9.9	4.6	4.1	<0.05	<0.05	2.85	<0.05	7.3	NA	45.3	7670.0	2540.0	4170.0	8720.0	7180.0	751.0	2870.0	968.0	34914
EPA4-CL4	8/23/94	NA	5.78	<0.1	2.8	1.5	3.0	<0.05	<0.05	1.98	<0.05	0.9	NA	37.1	14900.0	2250.0	3670.0	8870.0	7760.0	710.0	2890.0	923.0	42010
EPA4-CL4	9/6/94	NA	5.90	0.1	7.6	3.3	2.4	<0.05	<0.05	2.35	<0.05	1.1	NA	7.6	7830.0	2220.0	3610.0	8090.0	7040.0	779.0	3090.0	1010.0	33677
EPA4-CL4	9/19/94	NA	6.27	<0.1	1.6	2.1	11.3	0.06	<0.05	<0.05	0.07	1.2	NA	<1.0	122.0	118.0	348.0	646.0	468.0	310.0	788.0	550.0	3350
EPA4-CL4	10/3/94	NA	6.56	0.2	0.8	2.2	10.8	0.07	<0.05	<0.05	<0.05	1.3	NA	<1.0	14.6	63.0	350.0	588.0	564.0	307.0	652.0	578.0	3117
EPA4-CL4	10/17/94	NA	6.41	<0.1	4.5	<0.5	11.9	0.10	<0.05	0.25	<0.05	5.5	NA	1.0	4020.0	1190.0	2160.0	4610.0	4250.0	427.0	1330.0	611.0	18599
EPA4-CL4	10/31/94	NA	6.52	<0.1	1.5	<0.5	8.3	0.09	<0.05	<0.05	<0.05	<0.5	NA	1.9	75.4	83.0	387.0	610.0	318.0	381.0	549.0	2878	5490
EPA4-CL4	11/11/94	NA	6.43	<0.1	1.7	2.0	9.3	<0.05	<0.05	<0.05	<0.05	0.7	NA	<1.0	22.2	41.4	134.0	235.0	202.0	369.0	577.0	440.0	2021
EPA4-CL4	11/30/94	NA	6.35	<0.1	1.5	<0.5	10.6	<0.05	<0.05	<0.05	<0.05	<0.5	NA	<1.0	8.5	26.9	103.0	205.0	136.0	302.0	731.0	453.0	1965
EPA4-CL4	12/12/94	NA	6.56	0.1	0.5	<0.5	9.6	<0.05	<0.05	<0.05	<0.05	4.3	NA	1.0	29.3	21.7	46.1	90.1	60.5	302.0	448.0	328.0	1327
EPA4-CL4	12/29/94	NA	6.70	0.1	0.5	<0.5	9.3	0.06	<0.05	<0.05	<0.05	5.5	NA	1.5	17.8	21.8	49.4	83.9	54.4	326.0	568.0	443.0	1566
EPA4-CL4	1/9/95	NA	6.78	<0.1	<0.1	<0.5	7.8	<0.05	<0.05	<0.05	<0.05	7.6	NA	1.2	6.3	11.6	25.9	33.2	26.6	308.0	372.0	309.0	1102
EPA4-CL4	1/25/95	NA	6.87	0.1	<0.1	<0.5	8.1	<0.05	<0.05	<0.05	<0.05	9.4	NA	<1.0	12.8	11.7	15.9	43.2	19.0	234.0	154.0	123.0	604
EPA4-CL4	2/6/95	NA	6.95	NA	<0.1	<0.5	8.4	<0.05	<0.0														

APPENDIX C (cont.)

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S ₂ O ₃ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEXT(MB)
EPAA4-CL4	2/21/95	NA	6.94	0.2	<0.1	<0.5	8.2	<0.05	<0.05	<0.05	<0.05	9.5	<0.5	<1.0	3.5	13.5	39.0	73.1	26.6	268.0	237.0	219.0	880
EPAA4-CL4	3/6/95	NA	6.86	<0.1	<0.1	<0.5	8.1	<0.05	<0.05	<0.05	<0.05	18.4	NA	1.0	1.6	9.3	13.7	26.5	9.6	288.0	236.0	189.0	775
EPAA4-CL4	3/22/95	NA	6.78	0.1	<0.1	1.2	7.7	0.07	<0.05	<0.05	<0.05	4.3	<0.5	<1.0	3.3	8.7	9.0	20.5	9.1	182.0	97.6	62.5	393
EPAA4-CL4	4/3/95	NA	6.74	<0.1	<0.1	<0.5	9.1	<0.05	<0.05	<0.05	<0.05	7.6	<0.5	<1.0	<1.0	7.4	9.1	18.6	6.5	210.0	118.0	81.5	451
EPAA4-CL4	4/17/95	NA	6.69	0.1	<0.1	1.1	8.6	<0.05	<0.05	<0.05	<0.05	1.3	2.8	<1.0	1.1	6.9	7.3	16.5	8.1	141.0	58.9	31.6	271
EPAA4-CL4	4/28/95	NA	6.84	<0.1	<0.1	1.6	9.6	<0.05	<0.05	<0.05	<0.05	3.0	2.5	<1.0	<1.0	7.0	7.1	16.5	2.4	265.0	235.0	167.0	700
EPAA4-CL4	5/12/95	NA	6.76	0.1	<0.1	<0.5	10.7	<0.05	<0.05	<0.05	<0.05	1.1	2.8	<1.0	<1.0	4.9	5.4	12.2	<1.0	116.0	50.2	29.1	218
EPAA4-CL4	4/21/96	NA	5.97	<0.1	<0.1	<0.5	22.7	0.50	0.50	0.77	<0.05	<0.5	<0.5	4.6	102.0	148.0	804.0	2380.0	291.0	194.0	398.0	217.0	4539
EPAA4-CL5	3/30/94	NA	5.90	0.2	2.2	1.4	1.4	<0.05	<0.05	0.18	<0.05	<0.5	NA	13.7	85.0	31.9	40.8	182.0	50.4	48.4	90.3	19.2	562
EPAA4-CL5	4/7/94	NA	6.28	0.1	1.8	1.7	2.4	<0.05	<0.05	0.15	<0.05	1.0	NA	9.3	84.6	38.1	56.5	161.0	70.4	8.9	136.0	19.3	584
EPAA4-CL5	4/11/94	NA	6.02	<0.1	1.8	1.1	2.2	<0.05	<0.05	0.26	<0.05	<0.5	NA	19.9	1110.0	296.0	516.0	1270.0	889.0	149.0	505.0	119.0	4868
EPAA4-CL5	4/14/94	NA	5.95	0.2	2.0	0.9	2.9	<0.05	<0.05	0.35	<0.05	1.9	NA	12.1	68.0	36.7	73.9	320.0	60.7	75.8	217.0	37.5	902
EPAA4-CL5	4/18/94	NA	5.75	<0.1	3.6	3.9	4.9	<0.05	<0.05	<0.05	<0.05	2.5	NA	63.9	8170.0	1860.0	2830.0	6190.0	4980.0	287.0	979.0	395.0	25755
EPAA4-CL5	4/21/94	NA	6.33	0.2	7.6	<0.5	43.4	2.46	1.10	1.09	<0.05	36.3	NA	14.8	3490.0	1880.0	3050.0	6320.0	5540.0	670.0	2200.0	795.0	23960
EPAA4-CL5	4/25/94	NA	6.40	<0.1	6.7	<0.5	63.3	0.94	0.17	0.54	<0.05	19.1	NA	4.9	562.0	839.0	1890.0	3740.0	3850.0	524.0	1510.0	588.0	13508
EPAA4-CL5	5/2/94	NA	5.81	0.3	1.5	<0.5	89.5	<0.05	<0.05	<0.05	<0.05	43.6	NA	<1.0	97.5	314.0	933.0	1630.0	2260.0	315.0	712.0	487.0	6749
EPAA4-CL5	5/16/94	NA	6.40	<0.1	0.3	<0.5	57.4	<0.05	<0.05	<0.05	<0.05	10.3	NA	<1.0	16.2	177.0	657.0	1090.0	755.0	287.0	655.0		

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	SO ₂ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEXTMB (ug/L)
Nitrate Feed	5/2/94	NA	7.54	0.4	<0.1	8.2	8.5	9.66	<0.05	<0.05	<0.05	10.0	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	5/16/94	NA	7.45	1.8	<0.1	1.1	9.3	7.06	<0.05	<0.05	<0.05	9.3	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	5/31/94	NA	7.75	0.3	<0.1	<0.5	8.0	9.86	<0.05	<0.05	<0.05	9.4	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	6/13/94	NA	7.66	0.7	<0.1	19.2	9.1	6.40	<0.05	<0.05	<0.05	8.9	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	6/27/94	NA	7.35	0.4	<0.1	2.4	9.0	9.53	<0.05	<0.05	<0.05	NA	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	7/1/94	NA	7.65	0.3	<0.1	1.1	9.4	6.43	<0.05	<0.05	<0.05	10.0	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	7/25/94	NA	7.53	0.3	<0.1	0.1	8.9	16.10	<0.05	<0.05	<0.05	9.6	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	8/8/94	NA	7.57	0.4	<0.1	<0.5	9.2	17.30	<0.05	<0.05	<0.05	9.2	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	8/23/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrate Feed	9/6/94	NA	7.37	0.8	<0.1	<0.5	8.6	19.10	<0.05	<0.05	<0.05	10.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	9/19/94	NA	7.36	0.4	<0.1	<0.5	11.2	18.80	<0.05	<0.05	<0.05	10.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	10/3/94	NA	7.37	0.4	<0.1	<0.5	10.0	16.60	<0.05	<0.05	<0.05	9.7	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	10/17/94	NA	7.22	0.4	<0.1	<0.5	9.0	18.80	<0.05	0.57	<0.05	10.0	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	10/31/94	NA	7.46	0.4	<0.1	<0.5	8.3	19.80	<0.05	<0.05	<0.05	9.8	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	11/11/94	NA	7.52	0.4	<0.1	<0.5	9.5	18.60	<0.05	<0.05	<0.05	10.2	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	11/30/94	NA	7.54	1.0	<0.1	<0.5	9.2	22.40	<0.05	<0.05	<0.05	10.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	12/12/94	NA	7.35	0.7	<0.1	<0.5	9.7	17.90	<0.05	<0.05	<0.05	10.3	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	12/29/94	NA	7.50	0.5	<0.1	<0.5	9.0	18.80	<0.05	0.11	<0.05	9.8	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	1/9/95	NA	6.98	0.8	<0.1	<0.5	6.8	19.30	<0.05	<0.05	<0.05	9.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	1/25/95	NA	7.66	0.4	<0.1	<0.5	8.1	16.70	<0.05	<0.05	<0.05	10.4	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	2/6/95	NA	7.62	NA	<0.1	<0.5	7.8	17.40	0.06	<0.05	<0.05	10.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	2/21/95	NA	7.57	0.8	<0.1	<0.5	7.8	6.33	<0.05	<0.05	<0.05	9.3	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	3/6/95	NA	7.57	0.7	<0.1	<0.5	8.2	17.30	<0.05	<0.05	<0.05	9.3	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	3/22/95	NA	7.67	0.6	<0.1	<0.5	7.5	17.70	<0.05	0.39	<0.05	9.7	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	4/3/95	NA	7.72	0.5	<0.1	<0.5	7.5	20.50	<0.05	0.29	<0.05	10.3	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	4/17/95	NA	7.54	0.5	<0.1	<0.5	8.1	21.60	<0.05	<0.05	<0.05	9.9	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	4/28/95	NA	7.52	0.5	<0.1	<0.5	11.5	12.90	<0.05	<0.05	<0.05	9.4	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Feed	5/12/95	NA	7.27	0.6	<0.1	<0.5	12.4	17.20	<0.05	<0.05	<0.05	10.4	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	3/30/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Control Feed	4/7/94	NA	8.09	2.3	<0.1	<0.5	93.7	<0.05	<0.05	<0.05	<0.05	8.7	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	4/11/94	NA	7.72	3.9	<0.1	<0.5	54.3	<0.05	<0.05	<0.05	<0.05	8.3	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	4/14/94	NA	7.37	2.2	<0.1	<0.5	90.3	<0.05	<0.05	<0.05	<0.05	7.8	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	4/18/94	NA	7.70	2.2	<0.1	<0.5	74.7	<0.05	<0.05	<0.05	<0.05	7.7	NA	<1.0	1.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1
Control Feed	4/21/94	NA	7.38	2.4	<0.1	<0.5	88.0	<0.05	<0.05	<0.05	<0.05	7.9	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	4/25/94	NA	7.47	3.0	<0.1	<0.5	9.0	<0.05	<0.05	<0.05	<0.05	9.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	5/2/94	NA	7.54	0.8	<0.1	<0.5	8.4	<0.05	<0.05	<0.05	<0.05	9.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	5/16/94	NA	7.50	0.8	<0.1	<0.5	9.1	<0.05	<0.05	<0.05	<0.05	9.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	5/31/94	NA	7.82	2.1	<0.1	<0.5	8.1	0.16	<0.05	<0.05	0.06	9.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	6/13/94	NA	7.49	0.5	<0.1	<0.5	94.0	<0.05	<0.05	<0.05	<0.05	7.4	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	6/27/94	NA	7.44	3.2	<0.1	<0.5	8.7	<0.05	<0.05	<0.05	<0.05	NA	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	7/11/94	NA	7.72	0.4	<0.1	<0.5	9.3	<0.05	<0.05	<0.05	<0.05	9.8	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	7/25/94	NA	7.62	0.3	<0.1	<0.5	8.9	<0.05	<0.05	<0.05	<0.05	9.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	8/8/94	NA	7.60	0.3	<0.1	<0.5	9.4	<0.05	<0.05	<0.05	<0.05	9.2	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	8/23/94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Control Feed	9/6/94	NA	7.47	0.5	<0.1	<0.5	8.9	<0.05	<0.05	<0.05	<0.05	9.6	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	9/19/94	NA	7.42	0.5	<0.1	<0.5	11.8	0.21	<0.05	<0.05	<0.05	9.7	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	10/3/94	NA	7.59	0.8	<0.1	0.7	10.0	<0.05	<0.05	<0.05	<0.05	9.2	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	10/17/94	NA	7.33	0.4	<0.1	<0.5	9.1	0.13	<0.05	<0.05	<0.05	9.5	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	10/31/94	NA	7.51	0.4	<0.1	<0.5	8.2	0.10	<0.05	<0.05	<0.05	9.2	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	11/11/94	NA	7.48	0.4	<0.1	<0.5	9.4	<0.05	<0.05	<0.05	<0.05	9.6	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	11/30/94	NA	7.50	0.4	<0.1	<0.5	9.2	<0.05	<0.05	<0.05	<0.05	9.7	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Control Feed	12/12/94	NA	7.43	0.4	<0.1	<0.5	9.7	<0.05	<0.05	<0.05	<0.05	9.7	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

APPENDIX C (cont.) WATER QUALITY DATA FOR PILOT DEMONSTRATION PROJECT

Well	Date	Water Level (ft from TOC)	pH	DO (mg/L)	Fe (sol) (mg/L)	Br (mg/L)	Cl (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	NH ₄ -N (mg/L)	PO ₄ -P (mg/L)	SO ₄ (mg/L)	S ₂ O ₃ (mg/L)	BZ (ug/L)	TOL (ug/L)	ETBZ (ug/L)	PXYL (ug/L)	MAXYL (ug/L)	OXYL (ug/L)	MESIT (ug/L)	PSCU (ug/L)	TMB (ug/L)	BTEXTMB (ug/L)
Control Feed	12/29/94	NA	7.48	0.6	<0.1	<0.5	9.6	<0.05	<0.05	<0.05	<0.05	9.2	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
Control Feed	1/9/95	NA	7.15	0.9	<0.1	<0.5	6.8	<0.05	<0.05	<0.05	<0.05	8.6	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
Control Feed	1/25/95	NA	7.60	0.4	<0.1	<0.5	7.1	<0.05	<0.05	<0.05	<0.05	9.8	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
Control Feed	2/6/95	NA	7.54	NA	<0.1	<0.5	8.9	<0.05	<0.05	<0.05	<0.05	10.1	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
Control Feed	2/21/95	NA	7.56	0.6	<0.1	<0.5	7.7	<0.05	<0.05	<0.05	<0.05	9.0	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
Control Feed	3/6/95	NA	7.55	0.5	<0.1	0.7	8.5	<0.05	<0.05	<0.05	<0.05	10.0	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
Control Feed	3/22/95	NA	7.65	0.5	<0.1	<0.5	7.7	0.12	<0.05	<0.05	<0.05	9.1	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
Control Feed	4/3/95	NA	7.74	0.4	<0.1	<0.5	7.5	<0.05	<0.05	<0.05	<0.05	9.6	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
Control Feed	4/17/95	NA	7.53	0.4	<0.1	<0.5	7.8	<0.05	<0.05	<0.05	<0.05	9.1	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
Control Feed	4/28/95	NA	7.53	0.4	<0.1	<0.5	11.5	<0.05	<0.05	<0.05	<0.05	9.1	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
Control Feed	5/12/95	NA	7.35	0.1	<0.1	<0.5	11.7	<0.05	<0.05	<0.05	<0.05	9.1	<0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1
Pre-C Water	4/8/94	NA	7.64	<0.1	NA	<0.5	6.7	0.08	<0.05	<0.05	<0.05	NA	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	NA
Post-C Water	4/8/94	NA	7.74	<0.1	NA	<0.5	7.0	0.07	<0.05	<0.05	<0.05	NA	NA	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	NA